The Welding Engineer

Edited by L. B. Mackenzie

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Buyers' Index

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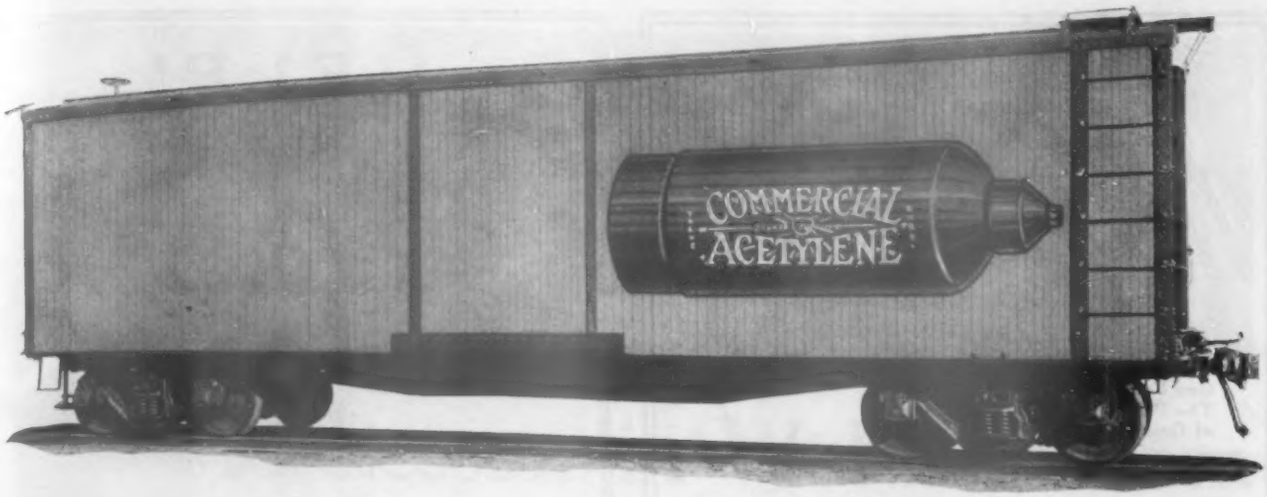

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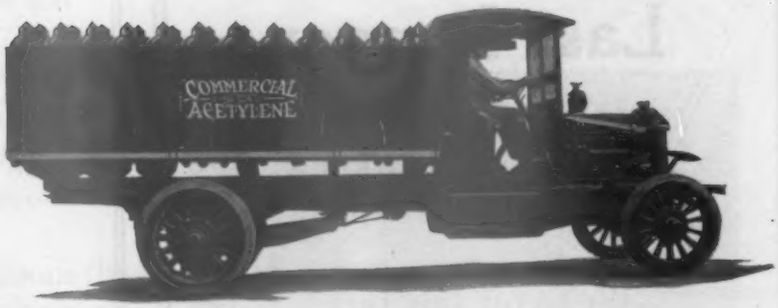

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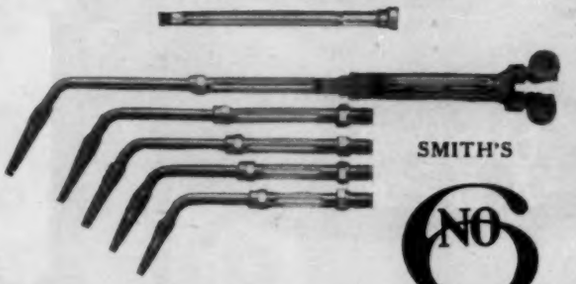

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Six In One For The Price of One

Why Smith Tips Last Longer

Here's a fact that every torch user ought to know. It's the way they're made.

Write for this fact.

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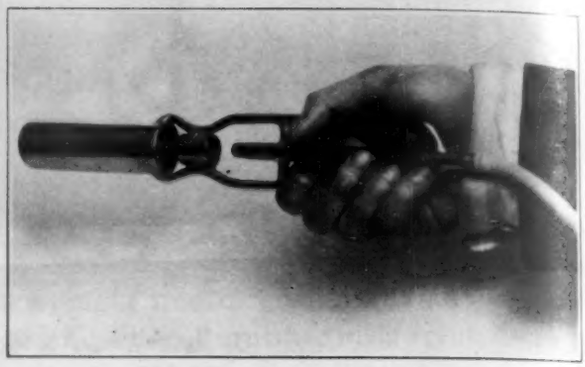

Every busy welder needs more heat for a few minutes on many a job—our

Acetylene Torch

works on 5 lbs. gas pressure, draws in free air. Produces very hot heat at low cost. Just the thing for close places—will not smother out—simple in construction. Price $10.00—use it 30 days. If not wanted, return it and get your money.

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LINCOLN ARC WELDER

A Lesson in Welding from The Standard Oil Co.

Few concerns have had more experience with welding or made closer study of it than The Standard Oil Co.

The above illustration is the result of a study on the costs of welding a piece of equipment which is called a radiator.

It is due to such figures that The Standard Oil Co. uses Lincoln Arc Welders in so many of its plants.

There is a lesson for any firm that wants to do welding at the lowest possible cost.

A radiator welded by The Standard Oil Co. of Indiana. Comparative costs by Acetylene and Arc Welding were as follows:

Cost of Acetylene Weld on Radiators

40 cu. ft. acetylene at .01	$0.40
48 cu. ft. oxygen at .016	.768
2 hrs. time at .45	.90
	$2.068

Cost of same with Electric Weld

16.6 K. W. H. at .006 per K. W. H.	$0.10
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the Strongest Bronze Made

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A strong weld of fine close grain and exceedingly tough texture is always the result where Cramp's Welding Rods are usesd.

We can also furnish Welding Rods of Cramp's Cast Iron, Cramp's Copper Covered Iron, Cramp's Vanadium Steel, Cramp's Drawn Aluminum, Cramp's Cast Aluminum, Cramp's American Iron and Soft Brass Brazing Wire.

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No. 8-G for Natural Gas, $8.00

LOOK

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FIRST: The use of a proper sized oxy-acetylene flame.

SECOND: The saving of gas by preheating your work for the oxy-acetylene flame.

The first is under your control in the use of the oxy-acetylene apparatus you have selected.

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Wanamaker Coated Electrodes
FOR
ARC WELDING

COATED WANAMAKER ELECTRODES

Reduce your labor costs.
Reduce your current costs.
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Increase your production.
Increase the operators' efficiency.
Increase the quality of your welds.

Write for details.

The new Tecor Specialties Bulletin describes the WANAMAKER COATED ELECTRODES, also a complete line of welding accessories.

Write for it today.

Transportation Engineering Corporation
15 PARK ROW, NEW YORK CITY.
608 SOUTH DEARBORN ST., CHICAGO, ILL.

Mr. Engineer:

IT is a fact that you can use gas for any welding job you may have, and obtain the most efficient results possible.

This is a well known fact, but it is not always understood by the mechanic who has welding to do. Some of them do not consider the value of efficient methods of operation.

Considering flexibility, adaptability, and economy of operation, you will find that gas welding is the universally accepted method, because it operates at greatest efficiency, and is applicable to any welding job.

The principal operators have found this to be true, and have established gas welding as a standard in their plants.

We suggest that you order your supply of oxygen or hydrogen from one of the manufacturers listed below, and determine to your own satisfaction why gas welding supersedes all other methods.

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Swift & Co., Chicago

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IOWA
Bettendorf Oxygen Hydrogen Co., Bettendorf

KENTUCKY
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Louisiana Oxygen Co., Inc., New Orleans

MANITOBA
Auto-Lite Gas Co., Ltd., Winnipeg

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National Oxygen & Machinery Co., Detroit

MINNESOTA
Commercial Gas Co., Minneapolis

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OHIO
The Clarke Chemical Co., Wickliffe
The Ohio Electrolytic Oxygen Co., Cincinnati

OKLAHOMA
Burdett Oxygen Co. of Oklahoma, Oklahoma City

OREGON
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Burdett Oxygen & Hydrogen Co., Pittsburgh, Pa.
National Oxygen Co., Erie

TENNESSEE
Burdett Oxygen Co., Chattanooga

TEXAS
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WASHINGTON
Washington Compressed Gas Co., Seattle

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He will tell what his laboratory tests show— that Standard Carbide is pure, clean carbide, free from the waste substances found in inferior grades.

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He will tell you two reasons why he uses Standard Carbide for acetylene welding and cutting. First, because his best workmen insist upon it. Second, because he finds it the most efficient and the cheapest. It costs the same as other grades and lasts longer.

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He will tell you there is a Standard Carbide warehouse in your district to insure prompt delivery and cut down freight charges. Also that Standard Carbide can safely be bought in large quantities as it comes in big blue, steel moisture-proof drums, and cannot deteriorate in any way.

Always packed in blue steel drums.

Ask us for any further information you may want

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Our experience as designers of electrical equipment dates back to the day when electric lights were a luxury and when electricity was struggling for a place in the sun. Westinghouse was a pioneer in electricity and its uses. Part of the knowledge accumulated during these years of experience is found in the design of Westinghouse Arc Welding Equipments.

There is a special scheme of field connections and a separate exciter that improve the stability, ease of striking the arc, and which assists the operator to consistently obtain sound welds.

The motor and generator used on these equipments are STANDARD. They are as reliable as the name Westinghouse in electrical design and construction.

Westinghouse Bulletin No. 7149 and No. 1826A describe this equipment in detail. Write our nearest office for them.

Westinghouse Electric & Manufacturing Co.
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Offices in all principal American Cities

Westinghouse
ARC WELDING EQUIPMENTS

A Definition of Service and an Illustration

Satisfactory service to-day and to-morrow must do more than merely meet a steady consumption. It should take care of emergencies arising from sudden demands, or rapid increases.

Recently a LINDE user located 50 miles from the nearest LINDE plant, received a large "rush" order for fabricated steel material. Being an up-to-date concern, they make generous use of the oxy-acetylene process.

One unit had to be shipped in 24 hours. The customary stock of oxygen was not enough to complete this unit, but LINDE Service responded to the emergency and the unit went out on time.

The LINDE Company's ability to supply oxygen in any quantity, anywhere, any time *without delay* is of special importance to-day.

No oxygen user, large or small, should close an arrangement for oxygen supply without first securing 1922 prices from the nearest LINDE District Sales Office.

[Nation-wide chain of 30 plants and 50 warehouses]

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District Sales Offices in these cities: *Atlanta, Boston, Buffalo, Chicago, Cleveland, Dallas, Detroit, Milwaukee, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco*

THE LARGEST PRODUCER OF OXYGEN IN THE WORLD

2204-22

GAS-ELECTRIC SUBMARINE TORCH*

Broken Siphon Pipe Burned Off by Electric Arc Under 50 Feet of Water—Great Advance in Submerged Metal Cutting

By Robert G. Skerrett

AS THE oxy-acetylene flame is capable of fusing its way through metallic masses of all sorts and divers thicknesses, whenever it can be brought into play in capable hands, it is not surprising that much experimenting has been done in the last decade to adapt the torch to the needs of the marine worker. This flame has been utilized extensively in cutting out the rivets of steel hulls, so as to hasten repair jobs and replacements; but as a rule this procedure has been confined to ships in dry dock or to parts of vessels that be approached in the open air. It has long been realized that much could be gained if a torch capable of working under water could be devised, for service in cutting metal bodies of

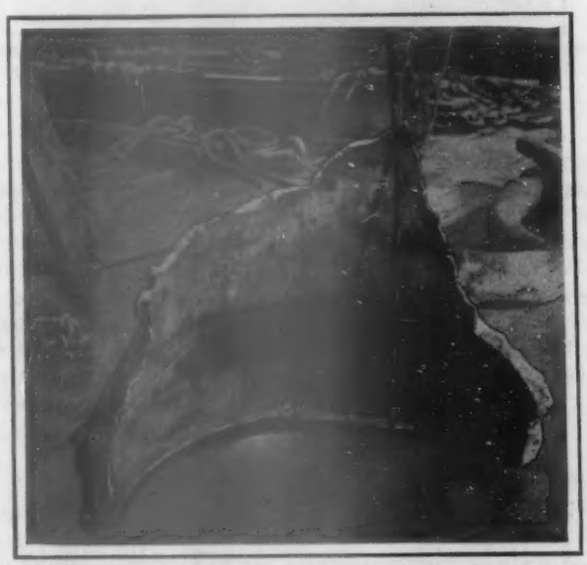
Hoisting from the Water the Broken Section of Pipe. The Bell Cut from the Next Section Is Seen at Top.

one kind or another. To this end, the Germans brought out some years back a submarine oxy-acetylene torch.

Broadly stated, the gases were discharged through a cup-shaped nozzle, and the flame was generated at the inner center of this vessel. The pressure of the expanding gases was relied upon to prevent the enveloping water from flooding the nozzle. Further, the force of the gas blast also served to wipe away or to scatter the metal made fluid by the heat of the flame. If the position of the nozzle opening or the impulse of the stream of gas was such that the water could inundate the cup, then the flame was extinguished and it was necessary to carry the torch to the surface to relight it.

In using this torch, care had to be exercised to hold the nozzle downward—at least not to raise its mouth above the horizontal. And the flame could not be kept alive unless the pressure of the repelling gases considerably overbalanced the submarine-cutting apparatus was found effective only at comparatively shallow depths. Nevertheless, the Germans pointed the way and proved that a bare flame could be kept burning when submerged. This much was clear gain.

The question is often asked: "Why try to cut metals with a flame under water when there are already available pneumatically-driven tools than can be utilized for such work?" And the query is a logical one, as compressed air must be used for the divers. Air-actuated tools have been built for service of this sort, but they are not commonly employed, for one reason or another. Mechanisms of this character are apt to clog with ice, owing to the refrigerating action of the rapidly expanding exhaust air, and this chilling is speeded up when the temperature of



This Portion of the Bell of the Broken Pipe Section Was Cut Off to Permit Easy Separation of the Broken Unit from the Next Intact Section.

the water is already low. Therefore, the idea of a submarine torch has appealed to the inventive mind.

During 1918 and 1919 the French naval authorities became much interested in efforts made at Lorient to improve upon the earlier German torch, and to devise comparatively simple attachments by which the ordinary oxy-acetylene torch might be operated under water in dealing with marine salvage problems, of which there were then many. After months of experimenting a measure of success was attained, and steelwork—parts of wrecked vessels—was so dealt with. That is to say, angles, T-bars, deck beams, etc., were thus cut through in a fairly rapid manner at depths ranging from 10 to 30. feet.

The nozzle finally evolved for the work was a double-walled affair, the inner tube constituting the flame chamber. From between this tube and the outer sleeve was discharged a stream of compressed air at sufficient pressure to form an atmospheric envelope for the flame. The force of this air held the water at bay while the torch reached the metal so bared.

While theoretically simple, the French torch was, in fact, complex, because it had to be supplied with acetylene, com-

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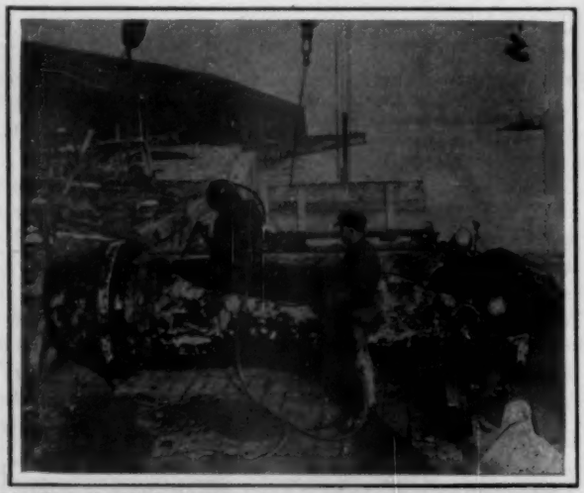
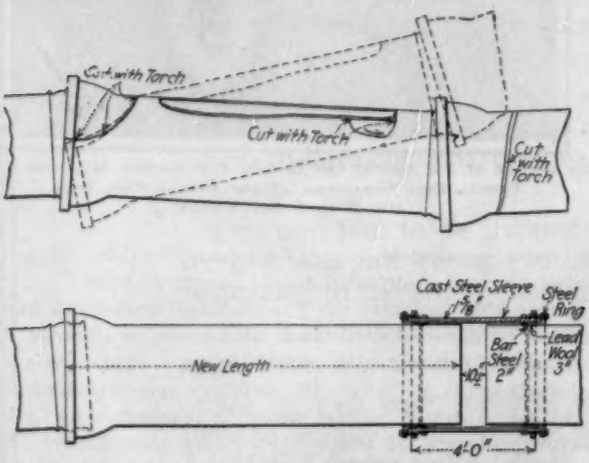
hydrostatic pressure at the operating depth. In short, this paratively pure oxygen and air, each at a different pressure. At a depth of 30 feet, the pressure of the acetylene was about 23 lb. square inch, while that of the oxygen and the air was much higher. The purpose in keeping the pressure of the acetylene as low as possible was to check its tendency



Illustrating the Method of Cutting from Outside the Pipe; the Lower Third of the Bell, at Left, Had to Be Cut from Inside the Pipe, the Diver Lying on His Side to Operate the Torch.

to explode rather than to burn as a flame. Indeed, this characteristic of acetylene has limited its subaqueous use; and, inasmuch as the pressure of the gas must be augmented as the depth increases, the operation of such a torch has been confined to submergences of less than 40 feet.

While the French found that their torch was apt to be extinguished if the nozzle touched the metal surface, yet the tip of the apparatus had to be held from it a distance of but a few millimeters. It has latterly been reported that they have improved upon the apparatus, so that it can be



How the Old Pipe Section Was Cut Out and Lifted; How the New Section Was Inserted and Made Tight.

ignited under water by chemical action; this obviates necessity for the diver to return to the surface to relight the gases. But there is nothing to indicate that this torch has yet gone beyond the experimental stage.

American Progress in Submerged Cutting

The foregoing resume of the art will help to a better understanding of what has been achieved here during the last few years. These steps forward have placed our engineers in a position to attack successfully certain difficult tasks under water; and the recent repair of the ruptured water main beneath the Narrows in New York harbor represents a climacteric performance. Staten Island, by reason of the break, was cut off from the Catskill water supply system for several weeks, and this period of isolation would, undoubtedly, have been a good deal longer but for the aid rendered by submarine cutting torches in facilitating the removal of the damaged piping.

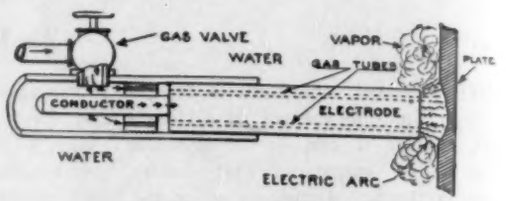


Diagram of the American Torch.

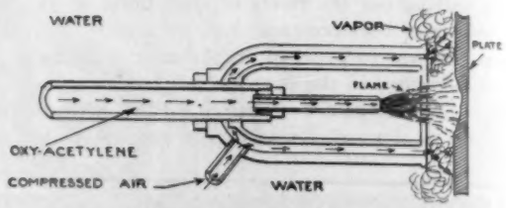


Diagram of the French Torch.

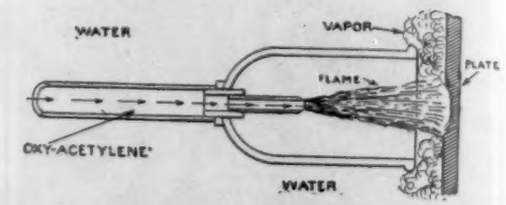


Diagram of the German Torch.

Three Types of Underwater Cutting Torches.

These torches are the outcome of experiments begun in 1918, during the refloating of the transatlantic liner St. Paul, which sank at her slip. For the purpose of draining that craft the divers blasted passages through various bulkheads. These holes allowed the water within the ship to move freely from one compartment to another so as to reach the suctions of wrecking pumps. But the salvors realized that this time-honored method of breaching steel partitions always did a good deal of damage and entailed correspondingly heavy outlays in making repairs.

Therefore Ralph E. Chapman, one of the engineering force of the wreckers, and J. W. Kirk, an associate, set about adapting the oxy-aceytlene torch and the electric arc for subaqueous service. The improvements evolved by them did much to insure a more nearly continuous working of the cutting flame; and by means of this apparatus 12 holes, each about 14 inches in diameter, were made through as many steel barriers. It took several hours to cut the average opening; some of the passages were located in decidedly awkward places; and the deepest of them were 50 feet under water. The torch was lighted below the surface electrically, both at the outset and whenever the flame was extinguished accidentally. However, experience revealed that the acetylene was troublesome at the lower depths, and for the reason already explained.

This introduction of the electrical feature marked an advance in the art; and between 1918 and 1921 the Merritt & Chapman Derrick & Wrecking Co., recognizing the desirability of such a tool for dealing with wrought iron and steel under water, gave Ralph E. Chapman a free hand in the further development of the torch. Last December, in its new form, the torch was put to a convincing test during the raising of the United States submarine S-48, which sank off Bridgeport, Conn.

To refloat that boat, it was necessary to drain the flooded

afterbody; and the primary problem was to get divers into the vessel to make a pipe connection so that wrecking pumps could be brought into action. The logical way to do this was through a hatch immediately over the inundated motor-room, but that hatch—at a depth of 70 feet—was sealed tight by a cast-steel cover locked in position from within the submarine. A hole was cut through the center of the heavy steel hatch cover by the new torch; and when this was large enough a diver reached in and released the locking gear.

The torch used on the submarine was simple in its get-up. Its operative parts, at the working end, consisted of a carbon electrode, a few inches long, traversed longitudinally by two small gas conduits—brass tubing about ⅛ inch in external diameter. The pressure and the quantity of gas conform with the operating depth. All the diver has to do is to bring his tool close enough to the metal to be cut to cause arcing; and the best effect is obtained when the electrode is something like ¼ inch away from the "ground." The electrode is connected to one pole of a generator, the other pole being grounded through the water to the work. Acetylene is not employed. The "cutting gas," of a nature not disclosed, is supplied from the surface through a suitable hose, within which is carried also the electrical conductor.

The temperature of the oxy-acetylene flame is in the neighborhood of 3600 degrees F., while that of the electric arc is more than 6000 degrees. The function of the gas used is to create a gaseous envelope for the arc, by converting the surrounding water into steam, and to oxidize and blow away the metal that is fused by the arc. Without this action of the gas, the fused metal would be apt to "freeze" quickly with the shifting of the electrode, and thus slow up the speed of cutting. The new torch is not hampered by hydrostatic pressure so long as the "cutting gas" has sufficient heat to vaporize the water, and force enough to blow the melted metal aside. A carbon electrode will last for 30 minutes of cutting.

The torch lately used on the Narrows siphon was much like that employed in cutting through the hatch of the S-48, save that it had to be modified slightly so that it could deal with thick cast iron. The remelting temperature of cast iron is around 2800 deg. Fahr.; and the higher the fusing point the faster a metal freezes, especially when acted upon by cold water. The problem, therefore, was to utilize as much of the heat of the electric arc as practicable in melting the cast iron, and then to scour out the molten crater by a suitably strong blast of "cutting gas." At the time the work was undertaken in February there was ice in the harbor, and the temperature of the water was close to 32 deg. Fahr.

Cutting of metal walls ranging in thickness from 1⅝ in. to 3½ in. was involved, the thinner body being severed at a linear speed of from 4 to 6 in. an hour, depending upon the ease with which the divers could get at their points of attack. All told, the divers made cuts aggregating nearly 30 ft. in length; and they were engaged on this phase of the task for the better part of ten days. One portion of the work involved cleaving circumferentially a section of the cast-iron pipe having an external diameter of 39 in.; this cut was made on a slant to facilitate lifting out the detached portion. The lower third of this cutting had to be done from within the conduit.

What Made the Job Necessary

Where the siphon nears the bulkhead line of the Staten Island piers, it rests 53 ft. below the surface of the water and is buried under 26 ft. of mud. By chance a dredge, engaged in deepening the overlying slip, hit one of the 12-ft. pipe lengths a shattering blow; the impact opened up a wide and long fracture. This necessitated shutting the gate valves at the Brooklyn and the Staten Island ends of the main. The question was, how to withdraw the damaged unit and to insert a new one in the shortest possible time, and with the least disturbance of the neighboring links? The Merritt & Chapman Derrick & Wrecking Co., which had laid the siphon, tackled the job.

First, a wide excavation was made in the harbor bed for the purpose of baring the injured pipe, and to give the divers a chance to work without fear of the mud sliding in on them. The blow that had fractured one pipe unit also forced the two contiguous ones downward out of line; and before any cutting was done the divers blocked these up. Next, the fracture was enlarged near the spigot end (right end, in our drawing) to form a hatchway through which a diver could get inside to cut the lower part of the adjoining pipe just back of the bell. Most of the upper section of the bell of the ruptured pipe length was then detached by cutting, including an enveloping wrought iron band 4 in. wide and 1½ in. thick. This work produced an elbow-like hollow which allowed sufficient play, when the opposite end was lifted, as shown in dotted lines, to break that lead-packed joint and to let the remaining part of the bell swing outward and free.

A new section was promptly lowered and installed in place of the fractured one, the joint at the bell being sealed with a packing of lead wool hammered home. The gap between the spigot end of the new unit and the pipe from which the bell had to be severed was bridged by a cast steel sleeve of ample length (5 ft.) to provide a strong union. The manner of making this connection is shown in the sketch. The bolts shown were used merely to equalize the space to be used for lead wool packing.

Before the repaired siphon was permitted to send water onward to Silver Lake reservoir, Staten Island, it was scoured out and sterilized. This was done by turning Catskill water into the siphon at Brooklyn and discharging it into a sewer at the Staten Island side by way of a 12-in. blow-off. When all of the mud and foul water were thus purged from the conduit, chloride of lime was added to the water entering at Brooklyn. This protective measure continued until tests showed the siphon to be absolutely clean. These steps were essential, for normally this siphon supplies some 125,000 people daily with the bulk of their potable water.

GROWING SUPPLY BUSINESS IN PHILADELPHIA

The U. G. I. Contracting Company, of Philadelphia, are reported to have entered the oxy-acetylene supply field in a very large way. One of the recent developments in their activity is the establishment of an oxygen manufacturing plant in Philadelphia. As they are distributors of Rego apparatus in that territory they are closely in touch with the market for gas. Business is said to be lively there for the heavy hitters.

G. P. A. ANNUAL JUNE MEETING

The annual June meeting of the Gas Products Association, will be held at Excelsior Springs, Missouri, on June 28, 29 and 30. From all indications this will be the liveliest and best attended meeting the association has ever had, and a cordial invitation has been extended to all associate members to be present at Excelsior Springs for the gathering.

ATLANTIC WELDED PRODUCTS COMPANY TAKEN OVER BY PENNSYLVANIA ELECTRIC WELDING CO., INC.

The possibilities of the Pennsylvania Electric Welding Co., Inc. of 416-8 Vine Street, Philadelphia, Pa., will be greatly augumented by the addition of the equipment and good will of the Atlantic Welded Products Company, which the former company has recently taken over. The improved concern will handle all types of production and repair welding. Their lines consist of boiler, automobile, tank and job repair work.

THE SCIENTIFIC SIDE OF WELDING*

What the Microscope Tells About Defects in Welds —Hammered Welds—Influences of Impure Gas

By E. Atkins*

(Continued from May issue)

Weld Defects

NOW we come along to deal with some of the defects that are found in welds which are the cause of their very low efficiency, either from the point of view of strength or toughness.

The micro. photograph Fig. 17 is of an acetylene wrought iron weld showing a layer of slag in between the weld and the bar, due to the surface of the bar not being properly fused before the filling material has been run in. A weld such as this, of course, simply falls apart under a slight pull or bend. This is shown in Fig. 18 where it will be observed that the actual fracture has taken place along the line of slag. Perhaps a better illustration of imperfect penetration in an acetylene weld is shown in Fig. 19, this being of a thick bar formed of a double "V." The bottom "V" was filled in fairly solid, but it will be seen that the root of the top "V" is unjoined, the filling having been run in without being fused to the bar.

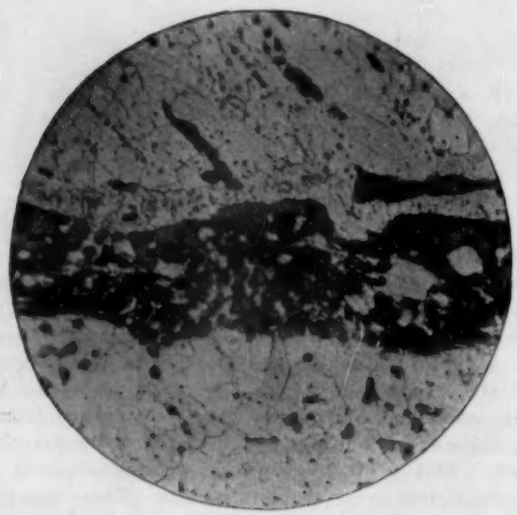


Fig. 17. Slag in Acetylene Weld.

Fig. 19. Imperfect Penetration in Acetylene Weld.

Sometimes in the welding of very common wrought iron, without the greatest care, the slag thread in the bar may be melted and run down at the junction of the bar and filling. This is shown in Fig. 20 where it will be noticed that the slag thread has practically been turned over at right angles along the junction. In arc welding, also, without great attention, slag may be included in the filling material, this is illustrated in Fig. 21 where slag ribbons are shown in the weld. In Fig. 22 a blob of slag in an arc weld is exhibited; this, it will be observed, having a distinct structure of its own. Included slag in a weld inevitably result in a weakening of the joint.

Fig. 18. Fractured Acetylene Weld.

Fig. 20. Slag in Bar and Weld.

Using an oxidising flame or prolonged playing upon the molten metal with a blowpipe flame, will result in the filling material of an oxy-acetylene weld being charged with oxide

*Lecture delivered at a general meeting of the British Acetylene and Welding Association, on Thursday, September 22, 1921.

†General Works Manager, Messrs. Rylands Brothers, Ltd., Warrington.

specks. These are seen in great numbers in Fig. 23, the metal being simply polished and photographed without etching. Welds of this description are bound to be of a brittle character. In addition to oxidising the weld, large grain growth is often engendered by prolonged heating, and this defect is shown in Fig. 24. If not badly oxidised a weld like this can be considerably improved by hammering. In connection with this the term "over-heating" should not be confused with that of "burning," although in practice it is very usual to use

Fig. 21. Slag Threads Through Arc Weld

both terms to cover the same phenomenon. When the metal is burned, hammering will not bring it back to its normal condition, and nothing short of actually remelting the metal and purifying it will restore its full properties. An illustration of the actual burning of a metal is shown in Fig. 25 which is of a weld in medium carbon steel, and if the same photograph is compared with that of Fig. 26 which is an acetylene weld

Fig. 22. Slag in Arc Weld.

of the same material that has been over-heated, it will be seen what a distinct difference there is in the resulting structure.

Through using a blowpipe flame with an excess of acetylene it is quite easy to carbonise a weld, which means that iron or mild steel in the molten state may have carbon added to it and be converted into high carbon steel. A good illustration of this is portrayed in Fig. 27 where, in the filling of the weld, the structure of every grade of carbon content from .10 per cent, right up to 1.6 per cent., can be seen. The .10 per cent composition is, of course, of very mild steel, and this structure is shown by the white area at the bottom of the photo. The dark zone in the centre is of pearlite which, as already mentioned, contains .89 per cent. of carbon, and the network at the top of the Fig. shows the hard carbide of iron structure together with dark areas of pearlite, the resulting carbon content being about 1.6 per cent. The surface of this weld was so hard that it could neither be filed nor machined. In passing, it may be mentioned that the use of the blowpipe under these conditions gives us at times a very ready method of case-hardening.

Difficulty is sometimes found in welding metals that have

Fig. 23. Oxide in Acetylene Weld.

been coated with other metals, and this is particularly so with tinned iron or steel. Careful investigation shows that the tin combines with the iron at the high temperature of the blowpipe, and forms not only a very hard compound, but also one of large crystalline structure. This is illustrated by Figs. 28 and 29. In Fig. 28 the hard compound of the

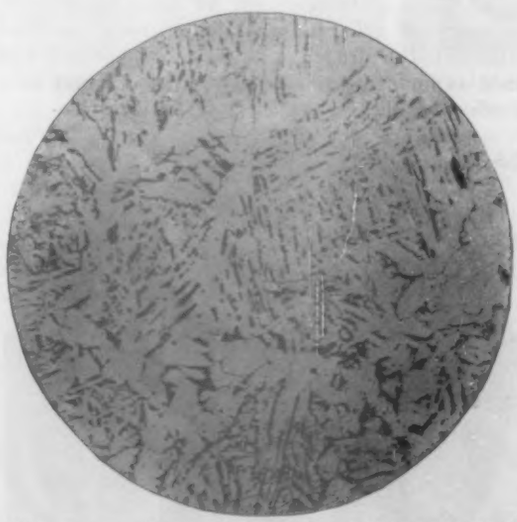


Fig. 24. Overheating in Acetylene Weld. Mild Steel.

weld is shown at the right hand with the large crystals, the left being the bar with the globules of slag. Upon stressing or bending the bar slightly, fracture results, and the reason of this will be seen in Fig. 29, where the little "blocks" of the iron-tin compound are shown separated from each other the crystals apparently being held together with very little tenacity.

Hammering of Welds

There is not the slightest doubt that the judicious hammering of either acetylene or electric welds of iron and steel immediately after they are made is a great advantage; this can be plainly seen by examining the micro-photos, Figs. 30 and

31, the former showing the structure of a steel just as welded, and the latter showing the fine grains set up by hammerings. When properly hammered the weld, of course, has altogether better mechanical properties in the direction of standing, bending or elongation. There is, however, one thing carefully to guard against, and that is the hammering of the weld at too low a temperature; this should cease before the material comes down to a blood heat, or just when the iron regains its magnetic properties in the form of attracting a small magnet. If hammered at too low a temperature incipient fractures will be set up in the metal as shown by the micro-photo. Fig. 32.

Fig. 25. Burning in Acetylene Weld.

Effects of Impure Acetylene

Torch welders ought carefully to guard against using impure acetylene, as there can be no doubt whatever that the molten metal can take up both sulphur and phosphorus from the sulphureted hydrogen and the phosphoreted hydrogen contained as impurities in the acetylene. Careful tests have been made with the results as tabulated below:—

Fig. 26. Overheating in Acetylene Weld. Medium Carbon Steel.

Effect on Deposited Metal of Pure and Impure Acetylene and the Electric Arc.

Carbon	.20	.08	.06	.105	Trace
Silicon	.04	Trace	Trace	Trace	Trace
Sulphur	.063	.009	.012	.10	.011
Phosphorus	.035	.012	.011	.04	.017
Manganese	.40	.12	.12	.10	.05

Comparing the sulphur in the filling wire with the sulphur in the weld it will be noticed that this, through the impure acetylene, has been increased about ten times the phosphorus also being increased about three times. Placing these results by the side of those obtained when the same filling wire is used in an electric arc, it will be seen that there has only been a very silght increase both in the sulphur and phosphorus, this, no doubt, being due to these elements passing over from the plate to the filling. Attention might also be called to the different effects on the carbon and manganese under the three methods of welding.

Fig. 27. Carbonized Acetylene Weld.

To show what actually takes place in a plate and weld under electric arc welding conditions, a panorama method of taking four micro-photographs is adopted, these being taken from positions as shown in the diagram Fig. 33, covering a length only of ⅛" and crossing the junction. In No. 1 position, the structure of the plate, Fig. 34, is shown to be unaffected by the heat from the arc. At the right hand side of No. 2, Fig. 35, it will be seen that the structure of the plate is commencing to break down slightly under heat diffusion. In No. 3 position, it will be seen from Fig. 36 that the plate structure is completely diffused, whilst in No. 4 position Fig. 37, we come to the junction and weld. Immediately to the left of the weld it will be seen that the plate shows a large grain structure due to the metal being somewhat over-heated. This group of micro-photographs clearly show why a weld if properly made does not break at the junction, but more often pulls away at the plate on account of this being at one part in an annealed state whilst the adjoining part is somewhat brittle.

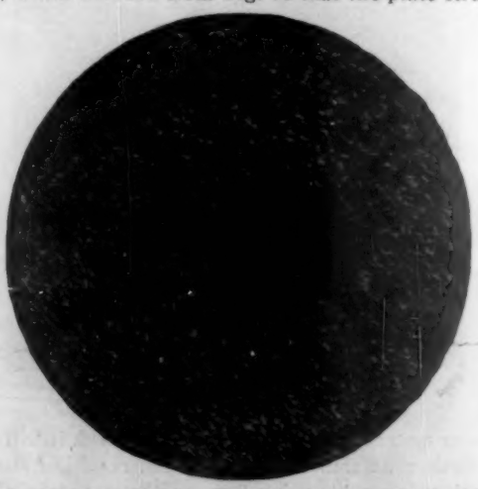


Fig. 31. Acetylene Weld in Medium Carbon Steel. Hammered.

Fig. 28. Welded Tinned Iron.

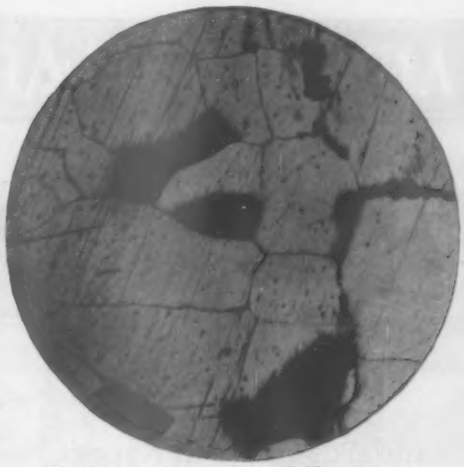


Fig. 29. Acetylene Weld of Tinned Iron.

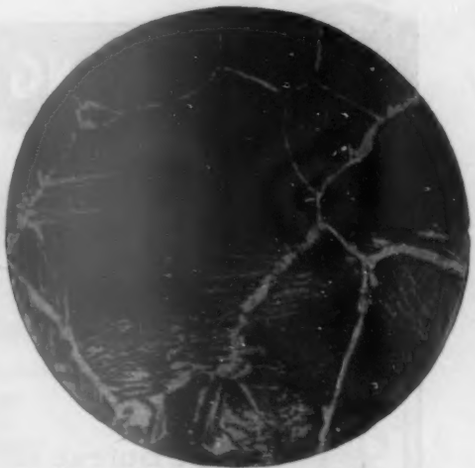


Fig. 30. Acetylene Weld in Medium Carbon Steel. Unhammered.

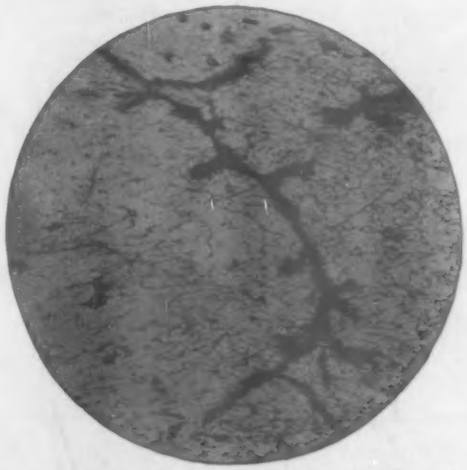


Fig. 32. Fracture in Acetylene Weld Through Hammering at too Low a Temperature.

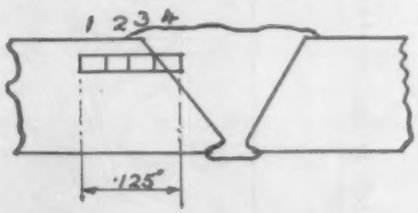


Fig. 33. Diagram of Arc Weld Showing Position of Micro-Photographs.

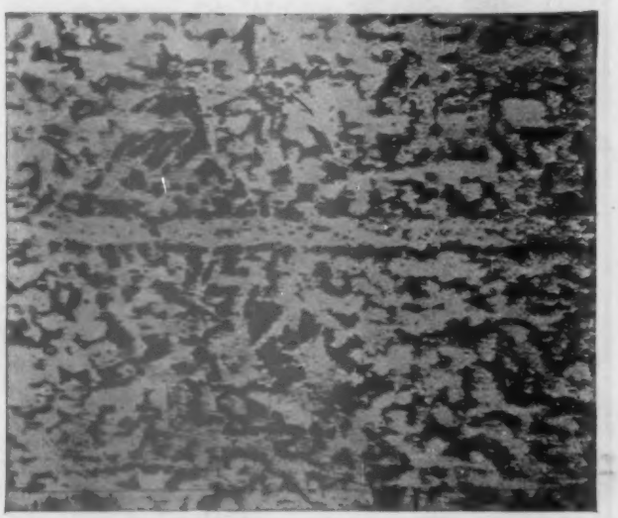


Fig. 34. Arc Weld. Plate Structure on No. 1 Position.

It will be noticed that the effect of heat diffusion travels to about one-sixteenth of an inch from the edge of the plate, and usually this is about one-half the distance that obtains in the case of oxy-acetylene welding.

To illustrate the effects of annealing on the material the weld in the last case was carefully annealed and then gave the structure as shown in Fig. 38. From this it will be observed that there is a distinct line of separation from the

Fig. 35. Arc Weld. Plate Structure at No. 2 Position.

Fig. 36. Arc Weld. Plate Structure at No. 3 Position.

WELDING AND CUTTING APPARATUS

The Bureau of Standards states in Report No. 200, page 94:

"With blowpipes furnishing THE ACETYLENE UNDER A HIGHER PRESSURE it is therefo re evident that the tendency to produce flash backs is minimized if not entirely suppressed."

REGO Pressure Chart

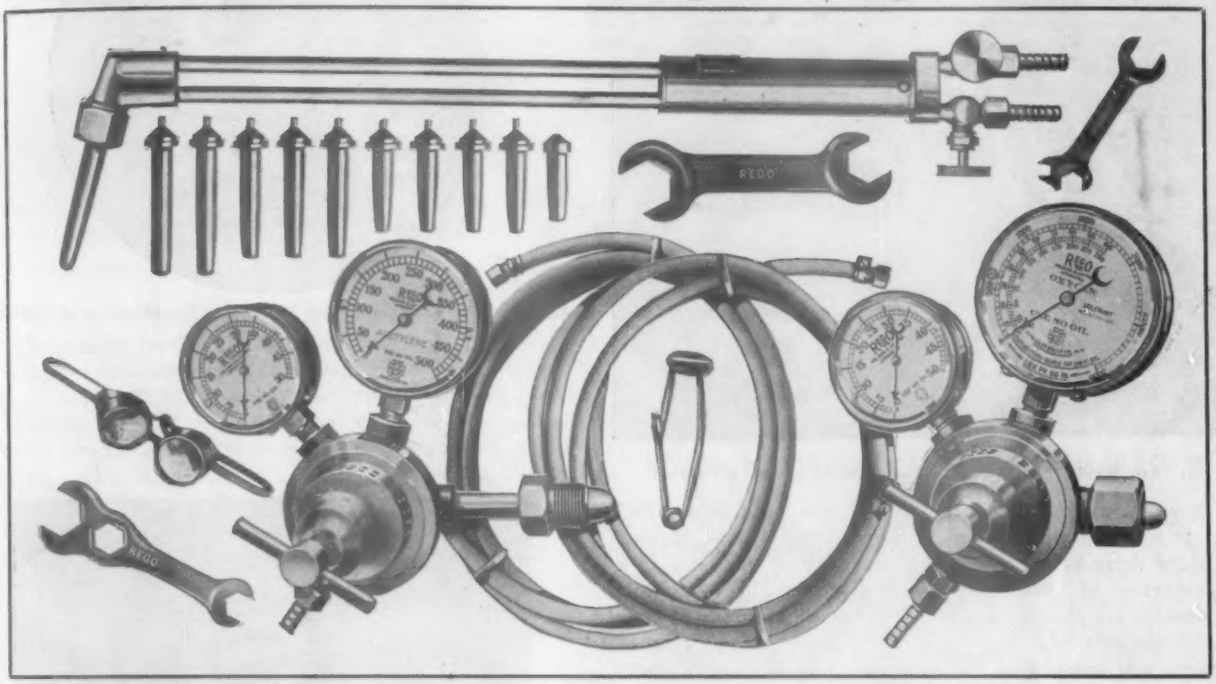
Tip No.	Pounds Acetylene Pressure	Pounds Oxygen Pressure
L-1	2	1¾
L-2	2¼	2
L-3	2½	2¼
L-4	3	2½
L-5	4½	3
L-6	5	4
L-7	5¼	4½
L-8	6	5
L-9	8	6½
L-10	9	7½

"If It's a REGO You Can Forget the Torch and Concentrate On the Weld Itself."

THE BASTIAN BLESSING COMPANY
WEST AUSTIN AVENUE AT LA SALLE STREET CHICAGO.

WELDING AND CUTTING APPARATUS

REGO Combination Welding-Cutting Torch $43.00



The REGO L combination Welding-Cutting Torch is **THE** torch for general welding and repair shops. This torch is designed for any range of welding work. There is no extra weight of high pressure cutting valve or cumbersome attachments to burden the operator. Changing the welding tip to a cutting tip changes the torch from a welding to a cutting torch. The high pressure cutting jet is regulated **IN THE TIP.**

REGO L torch with assortment of any desired 5 copper welding tips and one cutting tip..... **$43.00**

With tips 1 to 10 and cutting tip..... **$53.00**

Complete outfit No. 5 including torch, 5 welding and one cutting tips, 2 large size regulators with brass gauges, hose, wrenches and carrying case...**$105.00**

Complete outfit No. 5-A including torch, 10 welding tips, 2 large size regulators with brass gauges, hose, wrenches and carrying case.....**$110.00**

THE BASTIAN BLESSING COMPANY
WEST AUSTIN AVENUE AT LA SALLE STREET CHICAGO.

carbon, the black areas in the plate showing the pearlite or carbon areas, whilst in the weld above the carbon has disappeared.

A good deal has been said about the dissolving of nitrogen into the weld portion of an arc weld, and this is certainly proved both by chemical analysis and micro. structure. Fig.

Fig. 37. Arc Weld, Showing Junction of Weld at No. 4 Position.

39 shows a micro. photograph of one side of a double "V" electric weld, in which small nitride needles will be noticed. To show these better a micro. photograph of the same to a magnification of 1,000 diameters is given in Fig. 40, in this the needles are plainly seen and also two small blobs of slag. Careful analysis of the weld material gave .14 per cent of nitrogen and analysis of the electrode wire gave only about one-tenth of this amount. There can be no doubt that

Fig. 38. Electric Arc Weld Annealed.

occluded nitrogen is a cause of brittleness. Fortunately acetylene welders are free from this trouble.

A large number of experiments have been made to find out the relative effect of electric arc and oxy-acetylene welding on the material deposited. Some of these results are tabulated below and speak for themselves:—

Arc Weld on ¼ In. Mild Steel Plate
Asbestos Covered Electrode

	Plate	Filling Wire	Weld
Carbon	.12	.12	.038
Silicon	.047	.033	.045
Sulphur	.048	.015	.022
Phosphorus	.038	Trace	Trace
Manganese	.49	.34	Trace

Carbon loss, 68 per cent. Manganese loss, 98 per cent.
Silicon gain, 36 per cent. Sulphur gain, 50 per cent.

Fig. 39. Nitride Lines in Arc Weld to a Magnification of 1000 Dia.

Arc Weld on ¼ In. Mild Steel Plate
Flux Coated Electrode

	Plate	Filling Wire	Weld
Carbon	.19	.13	.12
Silicon	.18	.013	Trace

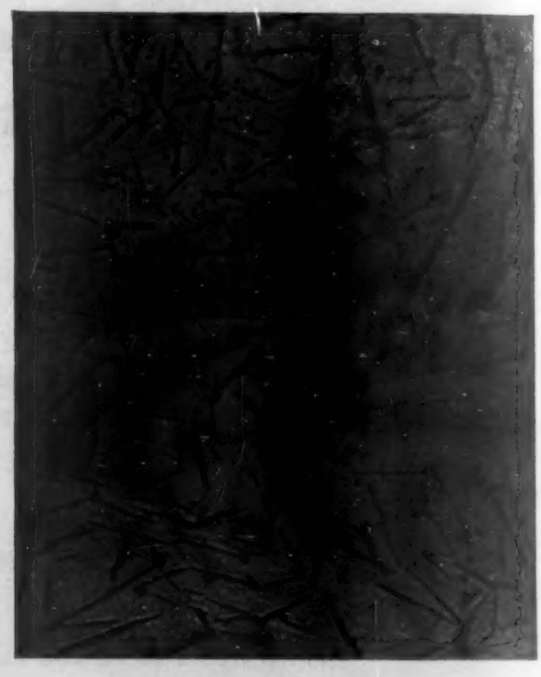


Fig. 40. Nitride Lines in Arc Weld to a Magnification to 1000 Dia.

Sulphur	.034	.022	.024
Phosphorus	Trace	.014	.011
Manganese	.49	.37	.25

Carbon loss, 8 per cent. Manganese loss, 32 per cent.
Silicon loss, 98 per cent.

Oxy-Acetylene Weld on ¼ In. Wrought Iron Plate
No Flux Used

	Plate	Filling Wire	Weld
Carbon	.034	.13	.08
Silicon	.12	.013	Trace
Sulphur	.023	.022	.02
Phosphorus	.068	.014	.016
Manganese	.15	.37	.13

Carbon loss, 38 per cent. Manganese loss, 65 per cent.
Silicon loss, 98 per cent.

(To be continued.)

WELDERS SNATCH LOG-LOADER FROM JUNK PILE

The Bennet Auto and Machine Company, of Hattiesburg, Mississippi, have made a reputation for themselves in that city as master welders. One of their recent achievements was the welding of two eight-ton log-loader bases for the Finkbine Lumber Company of Wiggins, Miss. Evidently this piece of work had always enjoyed a place in the category of things which "couldn't be done," for one of these pieces had lain on the junk pile for about seven years. Messrs. Travis and Roby, owners of the welding shop, tackled the contract of welding the old base and another one which had just been broken, and made a success of both. Thirty hours of welding time were put on the job, which consumed 125 pounds of cast iron, 1,180 feet of acetylene, and 1,590 feet of oxygen. This is considered a record for heavy welding jobs in that vicinity. Three views of the operation are shown herewith. "To see the difference in the loader a few days ago," says the *Hattiesburg American*, "and see it now, ready for operation, shows the remarkable work that was done by the welders."

The Casting on the Junk Pile.

Preheating the Break.

The Casting Ready for Service.

Mr. S. E. Travis writes the following interesting description of the work:

"The entire job (welding two of the loader bases) covered four and one-half days, the first being spent in packing equipment here for the start and in chipping the casting and setting it up for preheating. The total length of the break was 85 inches, this, of course, including web members etc. This chipping was done with an air hammer. The casting was then blocked up, the table or track side up, and clear of the ground about two feet, the detached section placed with a proper allowance for contraction and tacked in place with a torch.

"A furnace about five feet in diameter was built around and over the break and filled with charcoal, which was lighted about three in the morning. At six thirty actual welding work began and lasted without a stop until nine thirty in the evening, one welder doing the work with the writer acting as relief occasionally.

"It was necessary to work the casting from three different positions; this furnished the biggest problem of the job. Both faces had to be welded and the web members were broken also. As most welders know a casting weighing approximately eight tons, with fully two tons of it red hot and the rest too hot to touch, is no joke to handle. To take care of this, we built an overhead frame of strong timbers and mounted a high tonnage differential block on it above the casting. The bottom or track side of the piece was welded first, then lifted on edge as shown in one of the pictures long enough to weld the web. At this stage to prevent losing heat on the casting, two torches were brought into play, then the casting was pushed right side up where the other side was welded and hoisted back on edge, bricked up, and prepared for cooling.

"The cooling was also an interesting feature for the track or bottom of this piece was a heavy section, about four inches thick, while the web and other side were only 1¼ inches. Necessarily then, the thin sections could not be allowed to cool normally so heat was kept next them and the thick section heated by radiation only. In this manner the casting cooled in good shape and no contraction cracks showed up.

The above process was followed on the second casting with no changes of any import.

"The above process was followed on the second casting with no changes of any import.

"If you will note in the pictures, each end of the piece is built to take care axles and wheels and form the support of the entire machine, at this point our worst problem arose, to properly take care of the expansion and contraction so as not to interfere with the alignment of the wheels. At the conclusion of the job, after cooling, neither of the pieces varied more than one-sixteenth of an inch (we only had an allowance of three-sixteenths).

WELDING REDUCES COST OF REPAIRING MOTOR GENERATORS

Replacement or repair of substation equipment when auxiliary apparatus is not available was recently facilitated at the Bryant Street substation of the Market Street Railways of San Francisco by the use of welding, when trouble was experienced with some motor-generator sets.

Starting strains caused a loosening of the bars on the end rings of the squirrel-cage windings of the 2,150-hp. synchronous motors used, causing them to burn off. It was first recommended that the rings be replaced, but when it was taken into consideration that the machine on which the replacements were being made would be out of commission four or five days, it was found that this was impracticable, load conditions being such that all the generators were needed during the peak hours. Consideration was given to removing the field spools from one motor at a time, sending them to an outside shop to be welded. This also proved impracticable.

The work was finally performed by welding. Preparatory to this plates of sheet iron and asbestos to insulate the coils from the heat were made and a blower was arranged to supply a blast of cold air through the coils while the work was in progress. The actual welding was done during off-peak hours. The stator was moved forward by jacking, allowing the squirrel-cage winding to project 2 in. From four to six coils were welded an hour, each coil having four bars. The stator frame moved in both directions to allow welding the bars at both ends.

Each of the five motors on which the work was done was out of operation but four hours, two hours in the morning between load periods and two hours in the afternoon. Approximately twenty hours was required to complete the work on the five motors. The cost for the entire job of welding on the five motors was $100, or $20 per motor. It was estimated that the replacement cost of the worn parts would have been $200 per motor, or $1,000.

According to J. E. Beckman, chief operator for the traction company, welding of the worn parts has improved the operation of the motors more than replacement would have done. Contact is better as a result of the weld than if new parts had been installed and riveted. The motors also start more quickly and with less danger of short-circuiting.—Electrical World.

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Production Welding on Sheet Metal

NOW that business has picked up to an appreciable extent in nearly all industries job welding shops are finding an increasing demand for their services in various kinds of production work. One of the most common production orders is the fabrication of thin sheet metal containers. There is no limit to the variety of shapes, sizes, and designs, and apparently no limit to the uses for such containers. Good joints can be made so easily and quickly by welding, with a little practice, that most shops are on the lookout for some of this work. In fact it is claimed by some very successful shop owners that a welding shop cannot operate at a profit without having production orders on hand at all times, and that sheet metal work is about the most satisfactory. Naturally, the welder who understands how to cut, handle and assemble thin sheet forms will do more and better work, so it would not be amiss for the welder to do some private studying of the tinsmith's and sheet metal worker's trade.

The Usual Method of Doing the Impossible

WELDING Monel Metal by the metallic arc process has until rcently ranked fairly high among the list of impossible welds. Like a good many other impossibilities which faced the welding industry during the early years of its development—it has been done. Learning how to do it required two lessons, one to find out why it couldn't be done, and the other to remove the "why." Now that something definite has been accomplished it looks rather simple. Previous attempts to weld this alloy with the arc had resulted in deposits pitted with blowholes, due to excessive oxidation. Coating the electrode with a metallic "flux" overcame this condition and yielded a firm deposit which stood up creditably under a series of tests. Most likely the problem would have been worked out long ago if it were as simple as it sounds. It is still, strictly speaking, in the experimental stage, but well clear of the category of things impossible. Other impossible problems are receiving the same attention; thanks to the men who recognize the limitations of fusion welding as only temporary, the welding industry is progressing.

Suppose the Welder Made His Own Rules

AFTER the rules committees gets through, what then? Is the welder really any better off than he was before? or any worse? The matter of getting permission to make a weld in a certain place is not nearly so important as the matter of getting the ability to make a perfect weld in every place where a weld is specified. When the authorities let down the bars a little there is no cause for excitement, for rushing in to take advantage of every concession. It is, rather, time to get down to brass tacks and make good on every point. If the welders themselves were given full responsibility for establishing the limitations on their work, and especially on the work of their fellows, they would undoubtedly find themselves proceeding with the same caution which now seems irksome to them.

Let the Fall Meetings Start Strong

IT IS generally conceded that any attempt to hold large meetings through the summer months is waste effort, but it should not take two or three months to get started in the Fall. The membership committees and program committees have a fine opportunity to show their mettle through the vacation season without having to rush matters. Co-operation between these committees might make it possible to have enough funds in the chapter treasuries, and programs worked out far enough in advance so that before each meeting printed copies of each paper could be circulated to all members and prospective members. This is the only way to make sure of intelligent discussions, and one of the best ways to build membership lists and make the society worth while to the members.

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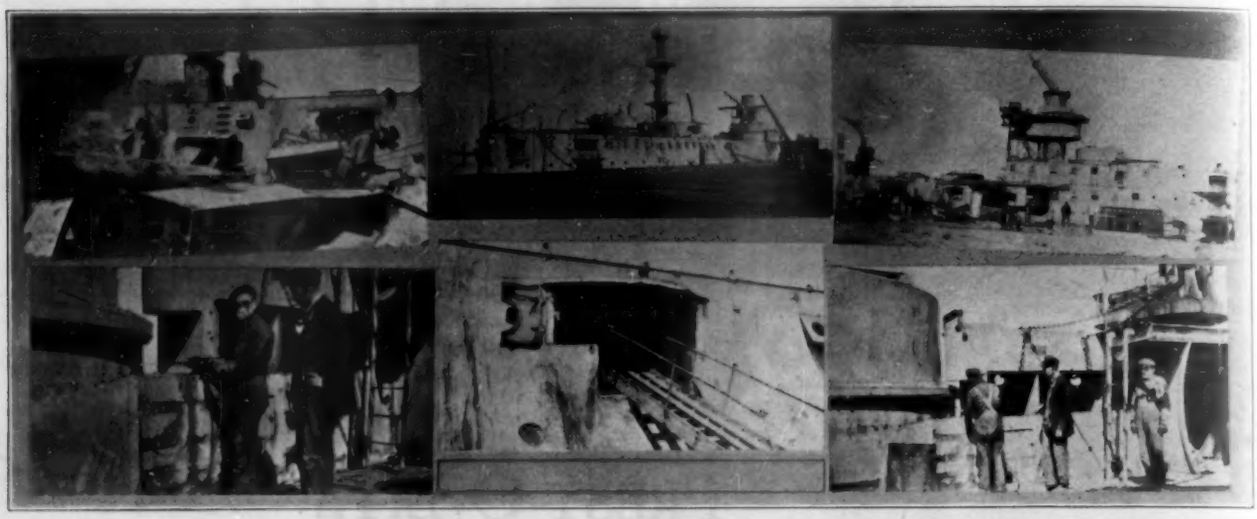
GRIZZLED OLD WARRIOR BOWS BEFORE GRIM REAPER

U. S. S. Brooklyn, Erstwhile Pride of the Navy, Invincible Against Spanish Armada at Santiago, Yields to Peaceful Wielders of Cutting Torch

With the cutting up into junk of the U. S. battle cruiser, Brooklyn, famous as the fighting flagship under Admiral Schley, there passes into the limbo of things departed a symbol of the new America, which in our generation has taken up the cudgels of war for the liberty of peoples beyond established American boundries. This grand old warship, obsolete though she has been these many years, still stands for the best traditions of the American Navy: for victory in defense of human liberties.



Views of Cutting Operations on the Brooklyn, One of America's Famous Fighting Ships.

The Brooklyn is one of the American sea fighters doomed to the junk pile by the recent Washington conference, and, constructed at a cost of more than $5,000,000 was sold for a paltry $40,000 to a California dealer in scrap metals. It is estimated that the ship will yield 6,500 tons of steel, and many tons of coppered brass, besides the miles of copper wire that were used in the electric signalling system. The great engines will also afford valuable salvage in the form of parts that can be removed without injury and sold for other construction.

The major part of the demolition work, including all cutting of iron and steel, is being done with oxy-acetylene cutting torches and at last reports the operators were making rapid inroads into the vitals of the old battleship. First to go were the funnels, each of which weighed approximately 18 tons. This step of the work was recently shown in the news films at moving picture theatres all over the country. More recently the six and eight inch armor plate on the ship's turrets was cut and it is interesting to note that the one man average per hour on this kind of cutting was approximately ten lineal feet. It is of further interest to oxy-acetylene operators to state that this cutting speed was attained with an oxygen pressure of only 85 lbs. In a general way the cutting that is being done on the old "Brooklyn" is typical of the work that is being done not only in the newly created ship breaking yards in this country, but in those of England and Japan, in the mighty undertaking set on foot at Washington early this year.

A number of pictures of the work in progress on the "Brooklyn" are shown in connection with this brief article. One shows the old craft, so mighty in its day, almost as it appeared before demolition was begun. Another shows a part of the main stack, atilt and about to fall after having been cut at the base of the section. This picture also shows a large supply of oxygen cylinders in the foreground.

CHASSIS WELDING

By S. W. Miller

A NUMBER of articles have appeared from time to time in the welding journals in connection with the welding of automobile frames, and a number of ingenious methods of reinforcement have been suggested, all of which are possible and which have, doubtless, given satisfaction. However, I have seen nothing in regard to the principles of reinforcing, and these should be considered so that the best method can be followed, if it can be applied. Of course, if it cannot be, some other less efficient means will have to be used.

An automobile frame is almost always either a channel or an I bean. The strength of a beam of any section depends on what is called its moment of inertia. This is a quantity which it is not necessary to explain, as it would involve considerable theory of the strength of materials. It is enough for our purpose to know that it is a measure of the strength of the beam. Full explanation of what it is and how it is used may be found in any mechanical engineer's hand book.

The reason for making I beams and channels is because the distribution of a certain amount of material in either shape gives a greater strength than when it is in the form of a flat plate or rectangular beam. It is also true that the deeper the beam for a given weight, the stronger it is. The moments of inertia of three shapes weighing 15 lbs. to the foot of length are given herewith:

6 in. I beam	24
6 in. channel	19.5
10 in channel	66.9
Flat plate on edge 6 in. deep, 7/10" thick	12.6

It is evident that the flat plate is by far the weakest. The strength of an I beam and channel is made up of the strength of the web and the flanges. In the case of the 6 in. channel, the moments of inertia are:

Web	6
Flanges	13.5

The weight of the web is about 40% of the total weight of the section, and this 40% gives less than ⅓ of the strength of the channel. This shows that if we want to increase the strength of a channel section, we can do so much more easily by adding metal to the flanges than we can by adding metal to the web, so that for the greatest economy of time and material, the reinforcing of a broken automobile frame should be done by welding a piece on the bottom flange which is where they usually break. This can be placed either on the inside or outside as may be best, but the outside is usually the easiest to get at.

Those of us who had anything to do with the manufacture

Achievement

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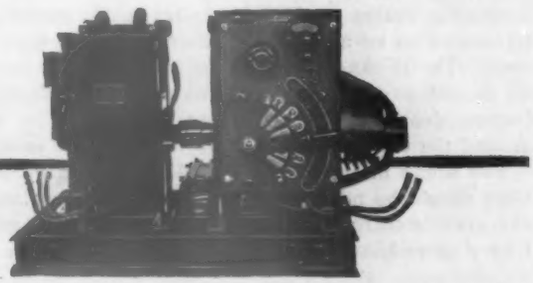
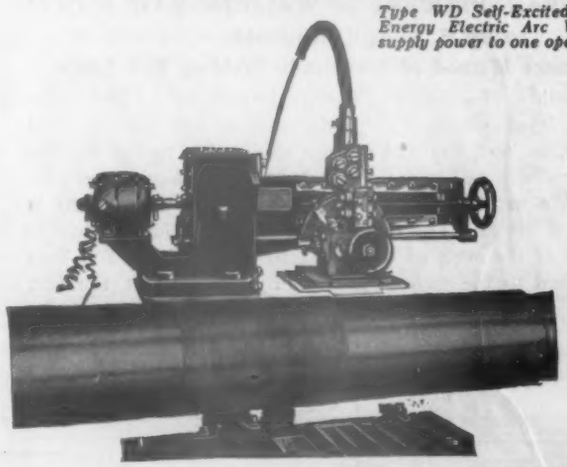


Type WD Self-Excited Constant Energy Electric Arc Welder to supply power to one operator.



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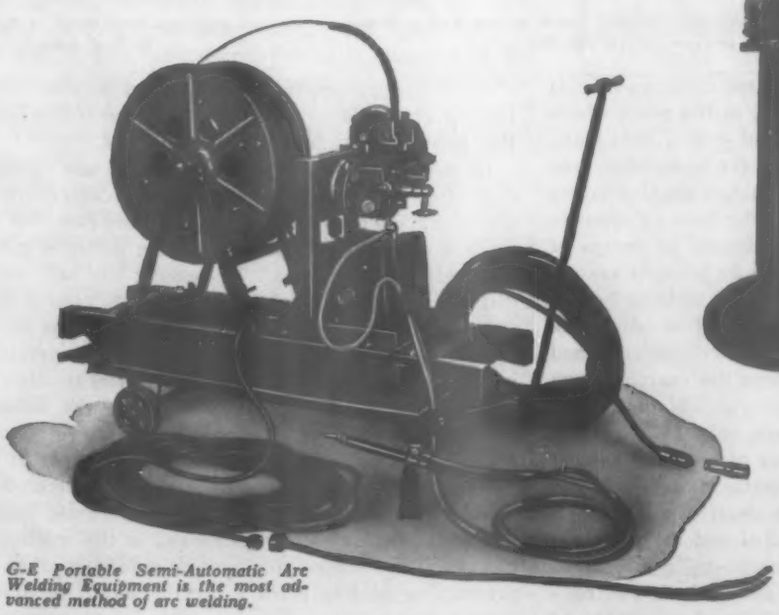

G-E Portable Semi-Automatic Arc Welding Equipment is the most advanced method of arc welding.

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or sale of bicycles in the old days will remember the strong talking point of the fish-tail reinforcement and on the same principle, that is, of not concentrating the strain straight across the tubing by a square ended reinforcement, the reinforcement on an automobile frame should be tapered on the ends. The thickness of the reinforcement may be about $\frac{1}{16}$" on an ordinary touring car frame and from ¼" up for truck frames, depending on their size. It should be welded all around the edge after the break in the frame is welded.

The break in the frame should be welded on both sides. Care should be taken, however, not to use any larger tip or any greater current than is necessary to make a sound weld. I have never known a frame so repaired to give any trouble.

THE LORAIN PROCESS OF WELDING RAIL JOINTS

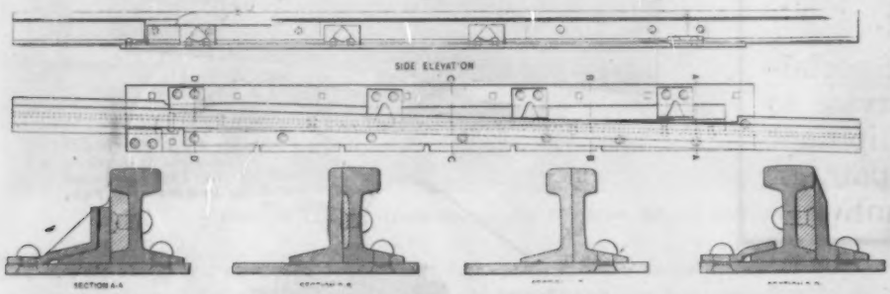
By H. F. A. Klienschmidt

Resistance Method of Electrically Welding Rail Joints

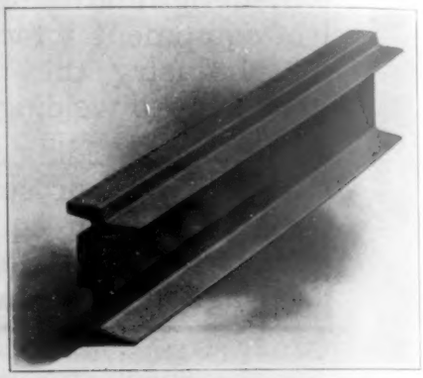
This method of welding rail joints, introduced by The Johnson Co. of Johnstown, Pa., predecessor of The Lorain Steel Company, in 1897, has had a large application to the welding of street railway rail joints, over 800,000 joints having been installed on a number of the largest street railway systems in the United States. The process consists in welding a bar to each side of the web of the rail across the joint. The bars are attached to the web of the rail by three welds, the first weld is made directly over the rail ends, the other two welds being at the ends of the bars. The rails, at the point where the welds are to be made, are first cleaned with a sand-blast, as are also the bars. The bars are then set in position, one on each side of the web, and the terminals of an alternating current transformer are clamped against the bars on opposite sides of the rail. These terminals are actuated by means of large levers so that hydraulic pressure can be brought against them to force the bars against the rail when a welding heat is reached. The terminals having been clamped in place, the current from a 200 K.W. inverted rotary converter is turned into the welding transformer, which steps the current down to about 7 volts with about 24,000 amperes. This current is confined to a small portion of the bars only by means of projections, or bosses, on the inner faces of the bars, so that the heating effect is localized to those portions only that are in contact with the web of the rail. In about two and a-half to three minutes a welding heat is reached and the parts are forced together under a pressure of about thirty-five tons. The area of the welds in each case is about three and one-half square inches. After the central weld has been made and before the bars have had a chance to cool, the ends of the bars are welded. In the case of the end welds however the pressure is allowed to remain in place for two to three minutes until the metal has cooled below a glowing heat, this having the same effect as the forging of the steel under a hammer and producing an exceedingly tough strong weld. After the bars have been welded in place the apparatus moves ahead to the next joint and a surface grinder restores the head, or running surface, of the rail. In cases where old track is being welded, the receiving rail is raised slightly above the other, so that by grinding away the metal on each side of the worn spot a true surface is restored. To further strengthen the rail at the joints a chock, fitting the under part of the rail head is welded in place at the time the central weld is made and gives a support to the rail head at the joints. With bars 1 inch thick and 3½ inches wide a tensile strength of about 330,000 lbs. is secured in the joint (in some cases joints have stood over 400,000 lbs., this being the capacity of the testing machine used). This is considered ample to overcome all stresses incident to changes in temperature between the hottest days of summer and the coldest days of winter. Where rehabilitation work, either on old track or on new construction, is to be undertaken on a large scale, this method provides a cheap and satisfactory way of making joints, as has been the experience of large users of this process.

Indirect Resistance Method of Butt-welding Rail Joints

A few years ago the Lorain Steel Company, of Johnstown Pa., bought the patents of the Jacobs Welding Company for the butt-welding of railway rails by means of interposing a flux between the rails to be welded, to obtain a uniform heat over the entire end sections of the rails. The process has since been perfected by the Lorain Steel Company and put on a commercially practicable basis and is now being applied. During 1921, joints were butt-welded on tracks in Johnstown, Pa., Boston, Mass., and Philadelphia, Pa.



Expansion Joint for Use in Connection with Electrically Welded Track Where Rail is Exposed As on Elevated Structures and on Interurban Rails.



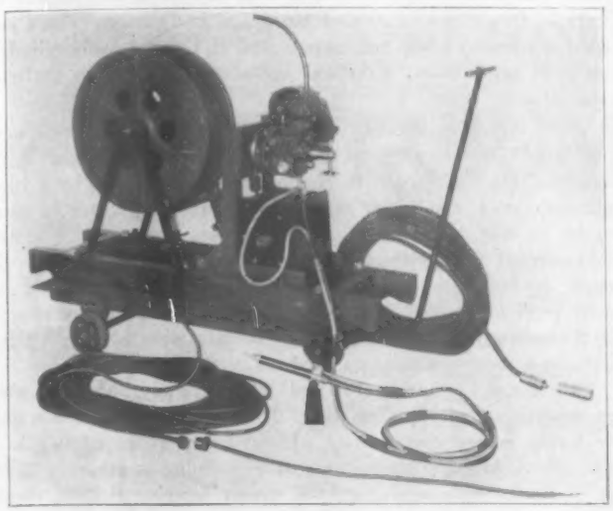
Section Through End Weld of Electrically Welded Joint.

In this process the principle is made use of that a certain flux after being melted and heated becomes a conductor of electricity, its resistance being such however that the current heats it as it passes through and the hotter it gets the lower the resistance becomes. By setting the rail ends a certain distance apart and applying clay molds around the rail ends the molten flux is confined so that it fills the space between the rails. The current from a 30 K.W. generator is turned into the rails and passes from rail to rail through the molten flux heating it to a high degree above the welding heat of steel. The end surfaces of the rails being in conact with this heated flux themselves come to a welding heat, at which time, by means of suitable clamps the rails are forced together, the molten flux being forced out from between them. As the rail ends are completely immersed in the molten flux no air can get at the heated steel and no oxidation takes place. The pressure is held in place a certain length of time thus producing the forging effect so essential to securing a strong ductile weld of high tensile strength. Experimental tests of a large number of butt welded rails have uniformily yielded a result over 402,000 lbs. tensile strength, this being the full capacity of the testing machine used. After the weld is made a grinder of suitable design removes the upset metal over the head and groove of the rail and restores it to its original shape. This method produces a butt-weld between adjacent rails in which the entire section is welded, without the use of any additional metal of any kind for making the joints. It

also enables the hot metal to be worked or forged after the weld has been made, thereby restoring the original properties of the metal after it has been heated to a welding heat. The current required for the welding of a 9 inch rail weighing 141 lbs. per yard is about 1,650 amperes at 40 volts, this current being on about three and one-half minutes to a weld.

PORTABLE SEMI-AUTOMATIC ARC WELDING SET

In order to increase the applicibility of its semi-automatic are welding apparatus, and make it available for use in any part of the factory, or shop, the General Electric Company is now building a portable set. This comprises a complete semi-automatic equipment, with support for a wire reel, mounted on a small truck that can be pulled over the shop floor by hand, or lifted by a crane. The complete outfit weighs about 400 pounds.



The G-E. Portable Semi-Automatic Welder.

The welding equipment consists of a semi-automatic lead, an automatic welding head, with control, and a standard for holding a reel of electrode wire. Power is supplied to the arc through a flexible cable with a plug for attaching it to the nearest welding circuit. The reel carrier is equipped with a brake, and designed to take any size reel up to 2½ feet in diameter.

The portable outfit should be valuable in repairing parts of machines in place when these parts are too bulky, inconvenient, or otherwise impractical to move, and for doing routine welding of all sorts, such as filling holes in castings, welding seams in pipes or tanks, or other work of a similar nature. Besides the saving in time and trouble due to the portability of the outfit, its use will save both time and material in welding.

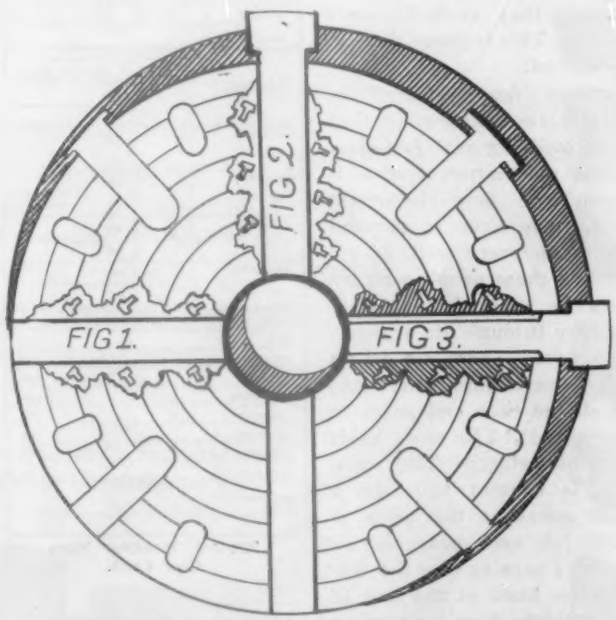
Time is saved, it is stated, because the electrode is fed continuously, and because the speed of deposition is from 25 to 100 per cent faster than that of hand welding. Much material is saved by the elimination of waste ends, which sometimes amount to from 10 to 25 per cent of the total amount of the electrode wire used. Also, since the welding operation is continuous, interruptions, which tend to affect the strength of the weld adversely, are greatly reduced.

LATHE CHUCK WELDING

By A. W. Young

In this article I shall endeavor to explain each step in the work so anyone not having experience on this kind of a job will be able to follow without any trouble, referring to the sketch as the work proceeds. Note first that the jaws were completely broken out. (Fig. I). First have several bolts tapped in the center of the break nearly at right angles to the surface. Next fit in a piece of carbon ¼-in. thick in the slide way below the breaks, (Fig. 2). It forms a bottom for the welded iron, at the same time leaving a good smooth edge to the underside of the jaw. Next fit on top of this another carbon shaped as Fig 3. This is so each side can be welded separately, not allowing the weld to extend clear across in one solid mass, which might set up a strain or warp. Should break extend to center hole of chuck, then brace up a piece of carbon or brick in the hole against the ends of the breaks, filling up uneven spots with fire clay so you can puddle iron without having it run out of the end of the slot. See that the center air hole is not entirely stopped up, as air space is needed in the center for combustion.

Build a furnace out of fire brick supporting chuck laying flat face up on four bricks on edge, see that the bricks support chuck on the thin parts, allowing the four thick parts fully exposed to fire. After laying first layer of brick of furnace, work the charcoal well into the center all around so as to get as even heat as possible. In firing up with the welding torch see that the charcoal is burning everywhere, and not in spots. You will have to look it over occasionally and sometimes have to use torch several times. This must not be neglected if you are to have a job not warped. Do not heat chuck hotter than when it commences to show a dull red in shadow, not in strong light. It is much more handy to have the asbestos lid on furnace in two pieces. They can be parted at point of weld, holding down the heat



Use of Tapped in Bolts to Increase Strength of Joint.
Typical Shop Cost Card.

and not exposing chuck to cold air on top. After weld is completed, have enough dry engine sand ready to completely bury the chuck. It smothers the fire, cutting off direct heat from the bottom and holding it down on top. It is now as near to the condition of a regular casting in sand as can be had. It is advisable not to take it out under 18 hours.

When chuck is taken out and laid on a level slab it should not rock a bit. This has been my experience. Some four months later a chuck repaired this way was caught and the other three jaws broken, the welded one holding against all the strain, which shows what strength is added by the tapped in bolts. I followed the same method on the other three and I don't think it will ever break again.

The National Oxygen Co., 12 East Harrison Street, Chicago, Ill., manufacturer of commercial oxygen, has purchased property in the Clearing Industrial section as a site for a new plant.

WELDING COSTS SYSTEMATIZED

Computing Costs is Not So Difficult as Many Welders Think, Provided a Good System is Used

Enroute, Minneapolis-Chicago.
Sunday.

Dear Ed:

I just finished up in Minneapolis after quite a stay there. Fact is, it took me much longer than I calculated. It wasn't so bad this time because it didn't rain all the time, like the last time I was there. Get acquainted with a young fellow who is connetced with a company manufacturing welding equipment. They maintain a welding shop in connection, where commercial work is taken in. This lad has run up against all the problems of a good sized shop and when he told me that next to getting "real-honest-to-goodness" welders, his greatest task had been figuring costs, I picked up my ears. Whoa! there, hold your horses, Ed, I fancy I know what you're about to say, that you've seen all kinds of cost systems laid out carefully in some of the trade papers and they don't interest you. Well, I've read some of them myself, but to tell the truth none of them seemed to "satisfy." If I can only tell you in the same manner as he told me, you will be vastly interested and you'll remember it too, because he made everything so doggone simple that anybody could get it. This is about the way it started:

"Very few welders," he said, "seem to appreciate that next to doing real first-class work, the matter of costs is about the most important thing they have to contend with. In every walk of life we find those people who are easily satisfied, content to journey through life at a certain level. There are others who always aim a little higher all the time and strive to get ahead! The same holds true of welders. The man who is content to make a wild guess at the price of each job and measures his month's earnings by the surplus on hand at the end of every thirty days, isn't going to progress as fast as the other fellow who goes after things with a system."

COST TIME CARD
WELDING COMPANY

JOB NO. DATE
ARTICLE
WANTED

	TIME	CLOCK TIME RECORD
PREPARING		OFF
		ON
WELDING TIP NO.		OFF
		ON
WELDING TIP NO.		OFF
		ON
FINISHING		OFF
		ON
FINISHING		OFF
		ON
TOTAL TIME		

IRON	LBS.
STEEL	LBS.
BRONZE	LBS.
ALUMINUM	LBS.
ASBESTOS	LBS.
CHARCOAL	LBS.
CARBON BLOCKS	
CITY GAS	FT
WELDERS NAME	

Typical Welding Shop Cost Card.

That's pretty good logic, isn't it, Ed? But at that, I'll wager I know just how your thoughts are running just as if you were sitting here in the train with me talking. I'm well aware that you always insisted that costs and charges couldn't be worked out well in welding, unless on a production basis because a welder is entitled to charge more on some jobs than others. That's a point where you and this fellow agree perfectly only he goes into it a little further and draws a dividing line, which I'm sure will hit you just about right. But why not give it to you as nearly the way he gave it as possible? That's what I'll try to do. He covered the whole "shooting-match" from "soup to nuts" so here you are:

"Say a customer came into my shop to have a piece of steel welded some day," he went on. "Let us assume it was a small part and required only a few minutes' time and very little gas to make the weld. A charge of one dollar is made; the customer pays and is perfectly satisfied. However, the following day he brings in another job. This also is a steel job, but the part is much larger and more costly than the first one, yet the amount of welding is the same. No preheating is necessary and, as a matter of fact, it takes no more time and gas than the first piece. The question I'm going to answer is whether the same charge shall be made in both cases, seeing the costs are the same, or whether the second job, with a greater saving to the customer, will not warrant a higher charge for the work.

"You'll probably think I'm a bit inconsistent when I tell you it's necessary to have a cost system in order to get and hold a trade, and then to turn about and suggest that on certain jobs let costs be forgotten and another basis used in figuring. That's just what I want to bring out though, and if I'm not sadly mistaken you will agree that the method I'm about to outline is perfectly justifiable.

'Now, if you've knocked about many welding shops," he went on, "you'll certainly appreciate what the average welder is up against. He can't spend much time doping out costs by a complicated system and rather than try, he simply takes a wild guess as to the cost of replacing and then makes a charge of one-half that amount for welding. I realized that such a method would never do, so when I came in here I figured it all out and the results seem to be very satisfactory. The proof of the pudding is in the eating, they say, so in order to determine whether a thing is to be a success it must be tried out.

"There are few welders, indeed, who have any idea as to what each job is actually costing them," he continued. "These men may be losing money continuously without being aware of it. As I just stated, in many shops the cost of welding is generally based on the price of a new part, the welder figuring that he should receive anywhere from twenty-five to fifty per cent of the cost of replacing, for his weld. Obviously this practice is wrong for the part broken may be of a rather heavy nature, yet costing little; in order to make a satisfactory weld considerable gas, material and time will have to be expended, in many cases this will amount to more than the cost of a new part, so it can readily be seen that if the welder charges only half the purchase price that he is more or less of a philanthropist. Again assuming that a weld of this nature has been made and the customer charged as indicated, just what will happen if a short while later the same customer returns with a much lighter part to be welded, but a replacement costing the same? If only half as much time, material and gas is used in this second weld, the customer, if he is blessed with any intelligence at all, will expect it to cost him less than the first, but when the cost is based upon price of replacing, there is no way out but to make the same charge. This manner of doing business in time will tend to strain the relations between customer and welder and it's the wise welder who will prepare himself with a good fair cost method and be consistent in his charges. In the long run he will be enjoying a good business while his competitor, who clings to a 'hit and miss' policy, will be forgotten, other things being equal.

"Computing the cost of welds may not be nearly so difficult as most operators suspect, providing a little system is introduced. In making the ordinary weld the cost can be readily divided into three elements, namely—time, material and gas, and it certainly will not require much effort to analyze these items a little further and determine the costs of each very closely.

"The question of 'time' is one which will vary in every shop, especially so, if overhead and profit is to be considered in it as is being done here. (Note: Overhead and profit can be figured entirely separate if desired, but in as much as they are usually represented by a percentage it may be easier to include them under 'time.') The actual time spent on the job during the preparation, welding and finishing is obtainable from the time clock, but the

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overhead expense will naturally depend upon just how much it costs the operator to do business every hour. The annual expenses, such as heat, light, rent, telephone, insurance, etc., should be classed as overhead. If more than one man shares this, it will be pro rata; if welding constitutes only one department, such as in a garage, then it should bear its share of the general overhead. Whatever this overhead may be, it should then be split up into a daily and then an hourly rate. Now if the welder gets sixty cents an hour and assuming that the overhead comes to the same amount a charge of two cents per minute would have to be made to actually break even. If a profit is to be considered it should be added to this rate, making the charge for time either three or four cents per minute.

"Material is intended to mean everything used in making the weld excepting the gas, this includes the rods, flux, asbestos, charcoal, oil, carbon blocks, city gas, etc. There should be no great question as to what the actual costs of these are, but too much time should not be given to checking these things up as it may mean more 'system' than business. Knowing that there are so many rods to the pound, the welder can easily estimate how much filler rod he used, etc.

"The next consideration is our gas. There are various means of determining how much gas is consumed, but probably the two methods which follow are the simplest and easiest to employ. However, before we find out how much gas is used on each job, we should first figure the cost of the cylinder of oxygen and that of the acetylene laid down in the shop. This means that several things must be considered in addition to the money paid to the gas producers. If the shop is in a small town, drayage on the empty tank to the depot, the transportation; return drayage and waste allowance for the gas left in the cylinder, all must be added to the actual cost of the gas at the recharging station. In estimating the cost of their gas, some welders do not include the drayage charge because they do the hauling themselves or have one of their own men do it for them. This is not correct, in as much as their time is probably worth just as much, if not more, than the drayman's. The amount allowed for gas lost and left in the tank will vary, depending upon the type of apparatus used, but taken on the average about five per cent of the total cost of the gas should suffice. Perhaps, if we tabulate our costs on a single cylinder it would look something like the following:

Drayage on empty tank going in	$0.50
Ingoing express	1.00
Cost of 220 cu. ft. @ 2 cents	4.40
Return express	1.00
Return drayage	.50
	$7.40
Allowance for waste gas, 5 per cent	.37
Total cost	$7.77

"From these figures you can see that the cost of the oxygen laid down in the shop is almost double that paid the charging station. Both the oxygen and acetylene gas costs are figured the same way unless a generator is used and then, of course, the carbide cost will be very much lower than the tank gas.

"One method of learning the cost of the gas used on each job is to depend entirely upon the reading of the high pressure 3,000 lb. gauge on the oxygen regulator. Assume that the same amount of oxygen and acetylene are used (such is the case in theory, but in practice there may be a slight variance) and divide the total cost of an equal amount of both gases, laid down in the shop, by two thousand, which is the number of pounds pressure in a full oxygen cylinder. If, for instance, a 220 cu. ft. cylinder of oxygen and a 225 cu. ft. tank of acetylene should happen to cost twenty dollars at the shop, then one cent per pound could be used, and, should forty-five pounds be indicated as the amount of oxygen used on any one job then forty-five cents could be taken to cover the cost of gas used on it. Some welders prefer to figure on making some of their profit on the gas charge, therefore they make it higher. With the above method it is necessary that gauge readings on the oxygen tank be taken before and after every job. (Note: The gauge on the acetylene tank does not indicate the true contents so cannot be used to figure costs. The only way dissolved acetylene can be measured is by weight, there being 14½ cu. ft. to the pound.)

"The second method mentioned for determining the gas cost consists of figuring out, by observation, the amount of gas each tip will consume per hour. Some apparatus manufacturers furnish charts giving this information, but it is best to check up under local conditions. Some welders consume twice as much gas as others, even where the same tips are used. If you don't believe it, test two operators out and be convinced. With the consumption data at hand, all that is necessary to know is the length of time the torch was used and the size of the tip. Where a time clock is employed or when there is more than one torch used off the same line, this is the logical way to arrive at the gas cost. This card is the one I drew up for the company and it has proved very successful. When a job is received by the office, a shop order is written out and the piece given a number. This number is on a metal tag and is wired to the job so it will not be destroyed if preheating is necessary. The same number is placed on the shop order and also on the cost card and is known by this number only, outside the office. By not knowing who the job is for the men working upon it do not show any favoritism. Neither do they get a list of the customers to use if they start up a shop of their own. As the work progresses, the details are entered on the cost card and when finished, the card is returned to the office where time, material and gas data are transferred to the shop order and the price made. This procedure may mean entirely too much 'system' for some shops and yet not sufficient for others, but by having something definite in mind and knowing the importance of costs, a means may be chosen which will do justice to both the welder and the customer.

"There are exceptions to all rules, however, and this includes welding. In many instances a welder is entitled to an extra charge for what might be termed his 'know-how.' A skilled welder might be rightly called a 'metal doctor.' Anybody may pick up a doctor's kit, but that don't make the owner a doctor. So it is with welding, the mere possession of the apparatus don't necessarily mean that the owner is a good welder. It is the 'know-how' based upon experience that really counts. Therefore, we find that welding jobs almost automatically divide themselves into two classes: ordinary jobs such as the average welder can handle and those requiring the services of an expert or one more skilled in the art. Now, if we handle all those jobs, included in the first class, on a 'time-material and gas' basis and let those of the second class have an additional charge made for the 'know-how,' we'll be sifting the thing down just about as close as anyone would care to have it. Take, for example, an aluminum crank case or a boiler worth hundreds of dollars; the average welder may not wish to assume the responsibility of undertaking such jobs for fear of failing. In a case of this kind the man who does, certainly should receive more than the usual rate, for he is more or less of a specialist in his line.

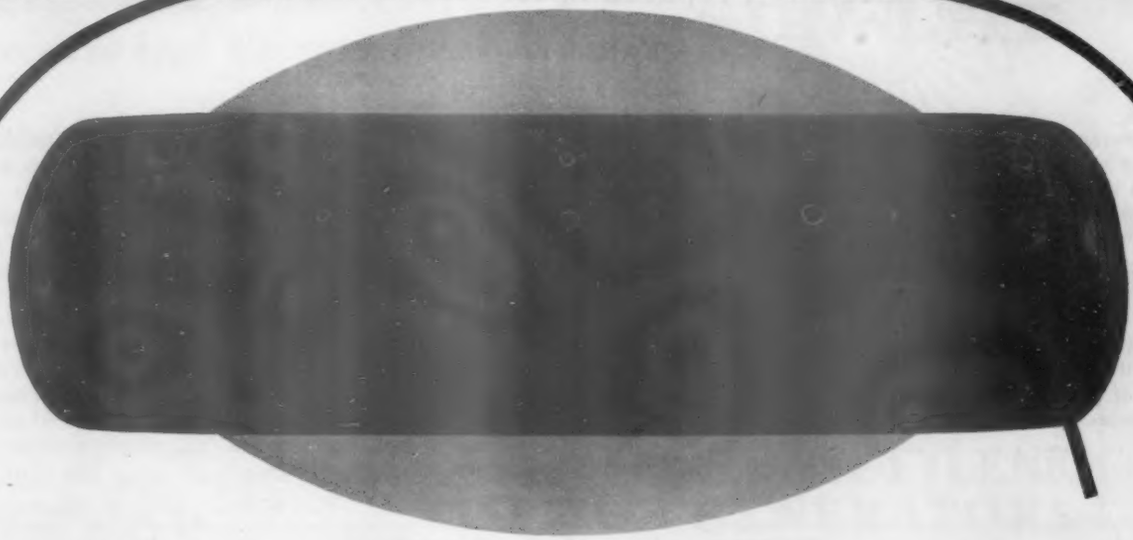
There you are, Ed, the dope is all yours. Most people have different ways of looking at things so perchance some of this lad's ideas may present the case in a little different light than you've been thinking along. As he says though, every shop is different, so a fellow has to give the matter a little thought and make the method suit his case.

Well, old boy, I feel as if I were going to have writer's cramp if I try to do any more writing. This train writing with your pad perched upon one knee isn't the easiest thing in the world, but I'll say one thing for it, it sures does make the time fly. As you may be sure I'm mighty glad to get back to headquarters once more and here's hoping that the boss don't conjure up any more of these long jaunts for "yours truly" for some time to come.

Bye Bye,

Shep.

Dependable Welds



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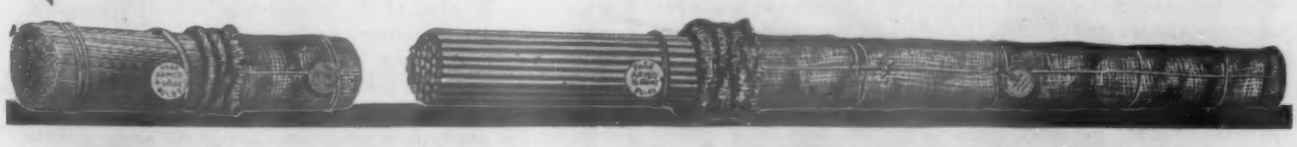

PAGE-ARMCO
WELDING RODS and ELECTRODES

Strength of Arc Welded Pressure Vessels*

Results of Tests on Electrically Welded Containers and Specially Prepared Specimens of Welded Metal

By R. J. Roark†

(Concluded from May issue)

16. Owing to the fact that the ends of the specimens were subjected to restraint from the wedge grips, the bending moment on the welded section was not equal to the load times the eccentricity, but was approximately two-thirds of this, as can be shown by the methods used in the analysis of statically indeterminate beams. The computed values of ultimate stresses were estimated on this basis. On account of the fact that the section extends for an indefinitely short distance, the actual stresses were undoubtedly in excess of those computed and the results are of value mainly as proof of the uniformity of the welds, as an indication of their behavior under such stresses and as showing the relative strength of the weld and the adjacent metal. In this connection, special mention may be made of specimens Nos. 11 and 14, photographs of which show that failure occurred through tearing or splitting of the metal in the shell, the weld remaining intact.

17. It is apparent that in the tests of these specimens the welded joints were subjected to an extremely severe test. It is not believed that a direct comparison between the loads sustained by the welded specimens and those sustained by the riveted specimens is significant. By changing slightly the eccentricity of the welded specimens—that is, by bending back the shell and head at a point nearer the joint—their strength in tension could be much increased. The test does subject the section A-A to a combination of bending and tension similar to that caused by internal pressure in the container but the bending moment is proportionally much greater. The test would have given conditions more like those existing in service had the eccentricity been made less, but owing to the thickness of the metal in the head it seemed advisable to make the necessary right-angle bend at the base of the flange.

18. Specimens of type B were tested in shear. The shear tool was designed to hold the specimen in such a position that the line of action of the applied load passed through the neutral axis of the section being tested. This necessitated inclining the plane of the section slightly and so introduced a small compression, but it eliminated the bending moment which would otherwise have existed. In general, the specimen failed in shear, as was intended, but in some cases it was found impossible to secure a shear failure, the adjacent metal crushing, tearing or bending before the weld gave way. The results secured from these tests are presented in Table 3.

TABLE 3 TESTS OF SPECIMENS CUT FROM CONTAINERS

RESULTS OF SHEAR TESTS ON SPECIMENS OF TYPE B

Specimen No.	Container from which Specimen was Cut	Dimensions of Specimen		Max. Load	Shearing Stress at Max. Load		Per Cent Variation from Average Strength for Linear In. Joint	Method of Failure
		Length of Weld *a* In.	Width of Weld *b* In.	Lb.	Lb. per Linear In. of Joint	Lb. per Sq. In. of Weld. Joint		
1	No. 4 — 16 inch	2.05	.....	35300	.....	.....	.....	Bent and crushed
2	gas welded	2.05	.....	36000	.....	.....	.....	Bent and crushed
3	(previously tested)	0.97	.....	27600	.....	.....	.....	Bent and crushed
4	weld by Le Quelle	1.01	.....	22000	.....	.....	.....	Bent and crushed
5	No. 5 — 16 inch	2.00	.....	22750	.....	.....	.....	Bent
6	gas welded	1.02	0.79	16350	16000	20200	11.0	Sheared
7	weld by Vilter Co.	1.00	0.82	19690	19700	24000	5.9	Sheared
8		1.02	0.97	20500	20100	20700	8.0	Sheared
Average					18600			
9	No. 1 — 16 inch	1.10	0.85	19560	17800	20900	5.3	Sheared
10	electrically welded	1.02	0.82	20150	19800	24100	5.3	Sheared
Average	(previously tested)	.....	.....	.....	18800	.....	.....	
11	No. 10 — 10 inch	.....	.....	16000	.....	.....	.....	Tore and bent
12	electrically welded	1.02	0.60	16870	16500	27000	7.8	Sheared
13	(not previously tested)	1.00	0.62	18180	18200	29300	1.7	Sheared
14		0.98	0.75	18600	19000	25300	6.1	Sheared
Average		.....	.....	.....	17900	.....	.....	
15	No. 3 — 16 inch	.....	.....	28900	12100	.....	.....	Sheared
16	riveted (previously tested)	.....	.....	28950	12100	.....	.....	Sheared
19	No. 11 — 10 inch	.....	.....	19800	8840	.....	3.3	Sheared
20	riveted	.....	.....	18150	8100	.....	5.4	Sheared
21	(not previously tested)	.....	.....	19400	8660	.....	1.2	Sheared
22		.....	.....	19300	8620	.....	0.7	Sheared
Average		.....	.....	.....	8560	.....	.....	

19. These tests gave definite information as to the shearing strength of the welded and riveted joints, and also enabled a study to be made of the homogeneity of the welded mass. In the case of the electrically welded specimens, the surface of fracture showed uniform cohesion and no flaws were detected. In the case of the gas-welded specimens which broke in shear (some could not be so broken) there were flaws or spots where the parts had not united. In neither the tension tests of the type A specimens nor in the shear tests of the type B specimens were the joints subjected to stresses precisely like those existing in the container. To secure precisely such stress would be very difficult and it is not necessary. The two tests represent the extreme conditions of pure shear and eccentric tension and so enable some comparison to be made as to the relative resistance of the different joints to the actual stresses, which are intermediate in nature.

*Paper presented at the Spring Meeting, Atlanta, Ga., May 8 to 11, 1922, of the American Society of Mechanical Engineers, 29 West 39th Street, New York.

†Asst. Prof. Mechanics, University of Wisconsin.

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20. It appears that the welded joints offered greater resistance to shear and that the riveted joints offered greater resistance to eccentric tension. As pointed out above, however, the actual strength of the welded and riveted specimens as determined by the test employed (tension tests on specimens of type A) are probably not fairly comparable. The advantage of the riveted joint as respects resistance to this kind of stress would undoubtedly be very much less marked if the eccentricity of the load were decreased.

Tests on Specially Prepared Specimens of Welded Metal

21. Two types of special specimens were tested. One was made by welding together a number of narrow strips of ⅜-in. plate edge to edge and then cutting from the composite plate so formed a number of strips perpendicular to the welded joints. As eight strips were welded together, each specimen had seven transverse welds in it. These specimens were tested in tension and the ultimate strength and per cent elongation noted. Eight specimens were thus made and tested, four having gas-welded joints and four having electrically welded joints. The results are presented in Table 4.

TABLE 4 TESTS OF SPECIAL SPECIMENS

Results of Tension Tests on Specimens Cut Transversely to Welded Joints

Specimen No.	Kind of Weld	Width of Plate In.	Thickness of Plate In.	Thickness of Weld at Fracture In.	Area of Cross-Section at Fracture Sq. In.	Ultimate Load Lb.	Stress at Ultimate		Per Cent Variation from Av'ge Strength per Linear Inch	Per Cent Elongation in 8 Inches
							Lb. per Linear Inch of Welded Joint	Lb. per Sq. Inch of Welded Joint		
1	Electric	1.51	0.39	0.50	0.75	22100	14600	29500	1.0	0.9
2		1.53	0.39	0.50	0.76	21100	13800	27800	4.5	0.5
3		1.51	0.39	0.50	0.75	21250	14100	28300	2.4	0.9
4		1.47	0.39	0.51	0.75	21250	14500	28300	0.3	1.1
Average		.....	.....	.....	.....	.....	14450	28175	.....	.....
1	Gas	1.51	0.39	0.34	0.51	19850	13100	39000	13.5	3.1
2		1.49	0.39	0.45	0.67	18850	12600	28100	9.2	2.5
3		1.50	0.39	0.36	0.58	12350	8250	21300	28.5	0.4
4		1.48	0.39	0.42	0.62	18100	12200	29400	5.7	2.7
Average		.....	.....	.....	.....	.....	11540	29450	.....	.....

22. In every case failure took place at or very near the center of one of the welds. As shown by the photographs, all specimens did not break on the same weld. No flaw was discovered on any of the fractured surfaces of the electrically welded specimens.

23. A cross-breaking test was made on one of the electrically welded specimens, the test piece being subjected to a center load on a 12-in. span, with the working side of the weld in tension. The specimen deflected without rupture about 3 in. under a load of 1,000 lb., indicating a modulus of rupture of something over 58,000 lb. per sq. in. for the metal in the weld. The dimensions of this specimen at a section through the weld at mid-span were 0.5 in. by 1.25 in.

24. The other type of special specimen was made by welding together two ⅜-in. plates edge to edge and cutting two pieces from the composite plate so formed, one along the center line of the weld and one from one of the plates, parallel to, but some distance away from the weld. Two sets of such specimens were prepared from plates electrically welded together and two sets from plates gas-welded together. One set of each kind was tested in tension, an extensometer being used and the proportional elastic limit, yield point, ultimate strength, modulus of elasticity, per cent elongation and per cent reduction of area determined. The results are presented in Table 5 and the stress strain diagrams shown in Fig. 7.

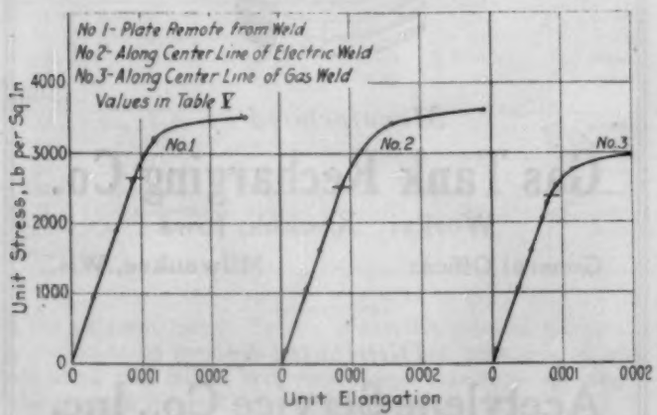

Fig. 7. Stress Strain Diagram for Special Specimen Cut Parallel to Weld Joints.

25. The remaining specimens were tested in shear. Two welding rods, similar to those used in making up the various containers and other welded specimens, were also tested in shear. The test consisted in subjecting the specimen to double shear while it was rigidly held in a special shear tool that prevented bending. The result of these tests are presented in Table 6.

26. Chemical analyses were made of each of the specimens of this type and of the two welding rods. The results are presented in Table 7.

TABLE 7. CHEMICAL CONSTITUTION OF SPECIAL SPECIMENS AND OF WELDING BARS

(Analyses by Robert W. Hunt Co.)

Specimen	Per Cent Carbon	Per Cent Manganese
Piece from center of electric weld	0.18	0.05
Piece from center of gas weld	0.06	0.08
Piece from plate remote from weld	0.12	0.51
Welding Bar No. 1	0.07	0.12
Welding Bar No. 2	0.07	0.05

Conclusions

27. Some of the more important points brought out by the tests are enumerated and severally discussed below.

1. Weak points in the containers.

None of the welded containers of standard design failed primarily at the welded head joint. The nature of the fractures shows that the weak points in the containers were, first, the lap weld in the pipe forming the shell, where failure occurred due to the circumferential tension, and, second, the body of the shell at its junction with the head flange, where failure occurred due to the combination of longitudinal tension and bending. It appears that leakage is likely to occur first where couplings and nipples are welded in. This is due to the fact that the metal of the shell stretches and pulls away from the nipple, which does not have a corresponding strain induced in it by internal pressure.

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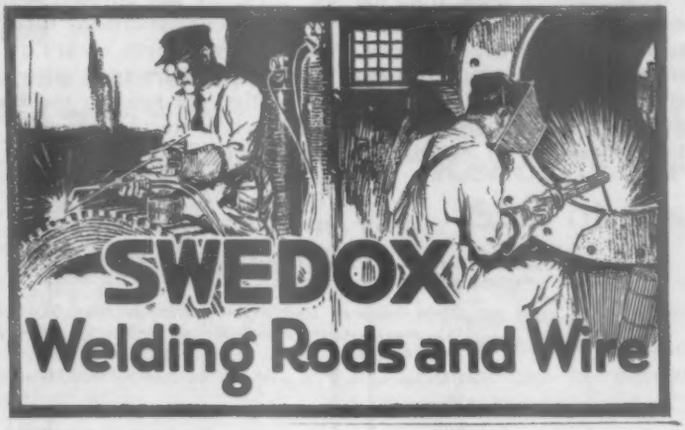

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2. Strength of electric welds.

From the tests on four especially prepared specimens, the average tensile strength of electrically welded joints was found to be 28,500 lb. per sq. in. From tests on five specimens cut from containers, the average shearing strength of electrically welded joints was found to be 25,500 lb. per sq. in. The mean variation from the average tensile strength per linear inch of weld was found to be 2 per cent, and the maximum variation 4.5 per cent. The mean variation from the average shearing strength per linear inch of joint was found to be 5.2 per cent, and the maximum variation 7.8 per cent. The results of eccentric tension tests on specimens cut from containers showed that no one of the specimens was markedly weaker than the average for the lot. It is believed that the uniformity of strength thus indicated is of especial interest and importance.

the riveted joint. Measurements to determine the elastic and permanent protrusion of the container heads showed that for the two specimens so tested, the welded container withstood a somewhat greater pressure without permanent distortion. In the case of the riveted containers, leakage occurred at the head joints under moderate pressures; in the case of the electrically welded containers there was no leakage at the head joint under any pressure.

4. Structure and physical properties of metal in the weld.

The microphotographs taken of sections through gas and electric welds, both chosen at random, show almost perfect uniformity of structure and freedom from iron oxide or other impurities. In none of the specimens of electrically welded metal where fracture occurred at the weld was there any indication of porosity, imperfect coalescence, or flaw of any kind. In the gas welded specimens tested in shear there

TABLE 5 TESTS OF SPECIAL SPECIMENS

RESULTS OF TENSION TESTS ON SPECIMENS CUT PARALLEL TO WELDED JOINTS

Specimen No.	Location of Specimen	Dimensions of Cross-section In.	Unit Stress at Proportional Elastic Limit Lb. per Sq. In.	Unit Stress at Yield Point Lb. per Sq. In.	Unit Stress at Ultimate Lb. per Sq. In.	Modulus of Elasticity Lb. per Sq. In.	Per Cent Elongation in 8 In.	Per Cent Reduction in Area
3	Along center line of gas weld.....	0.257 x 0.256	23700	36800	36800	29,000,000	1 9	6
2	Along center line of electric weld..	0.269 x 0.246	26000	43400	43400	29,000,000	2 1	7
1	In plate remote from weld.....	0.260 x 0.270	26700	39900	59400	29,000,000	9 0	9

TABLE 6 TESTS OF SPECIAL SPECIMENS

RESULTS OF SHEAR TESTS ON SPECIMENS CUT PARALLEL TO WELDED JOINTS

Specimen No.	Location of Specimen	Dimension of Cross-Section In.	Area Cross-Section Sq. In.	Load at Failure in Double Shear (Lb.)					Average Ultimate Unit Shearing Stress Lb. per Sq In.
				Load Applied Parallel to Plane of Joint		Load Applied Normal to Plane of Joint		Average of All Tests	
				1	2	1	2		
1	Along center line of electric weld	0.265 x 0.254	.0674	5840	5480	5300	5730	5740	42500
2	Along center line of gas weld..	0.259 x 0.268	.0694	6290	6410	6170	6400	6320	45500
3	In plate remote from weld	0.253 x 0.255	.0645	7500	7500	.....		7500	58100
4	Welding bar No. 1.....	0.186 Diam.	.0272	2580	...	. .	. .	2580	47400
5	Welding bar No. 2	0.186 Diam.	.0272	2600	. .	.....	..	2600	47800

In connection with the values given above for tensile strength two points should be noted. First, at the section through the weld, where failure took place, the load was eccentric, because of the fact that the specimen is asymmetrically thickened at that point by the joint. This eccentricity undoubtedly made the average stress on the joint at failure less than it would otherwise have been, and so the values obtained were less than the actual tensile strength of the metal. The effective eccentricity was not as great as one-half the excess thickness of the joint, because the ends of the specimen were restrained. No attempt has been made to allow for the effect of this eccentric loading, because it represents a condition inherent in any so-called single-V weld which has an excess thickness.

Second, each of the four specimens, had, within its tested length, several transverse welded joints. The strength of each specimen, therefore, represents the strength of the weakest of these seven joints, and so the value given, 28,500 lb. per sq. in., is less than the average strength for all the joints.

3. Relative strength of electrically welded and riveted joints.

The tension tests on specimens of type A indicated that the resistance to tension applied with large eccentricity is greater for the riveted joint than for the welded joint. The shear test on specimens of type B indicated that the resistance to shear per linear inch of joint is greater for the welded joint than for

were found spots on the surfaces of fracture where the parts had not united.

Specimens cut from along the center line of both electric and gas welds and tested in tension failed at their yield point, which was for the electric weld higher and for the gas weld lower than the yield point of the base metal as determined by test on a similar specimen cut from the plate some distance from the weld. The ultimate strength of the base metal was considerably higher and the percentage elongation much higher than for the metal from the welds. Shear tests showed that the metal from the welds was slightly inferior in shearing strength to the metal of the welding bars and considerably inferior to the base metal.

5. Efficiency of electrically welded joints.

While it is customary to speak of the efficiency of a joint, whether welded or riveted, meaning the ratio of the strength of joint to strength of plates joined, the writer does not believe that this ratio is especially significant in the case of electrically welded joints nor that any value can be given it that can be regarded as generally applicable.

It is apparent that while the strength of the plates joined is dependent solely on the physical properties of the base metal, the strength of the weld is in great measure dependent on the properties of the filling metal. Furthermore, the per cent excess thickness of the weld, which influences its strength,

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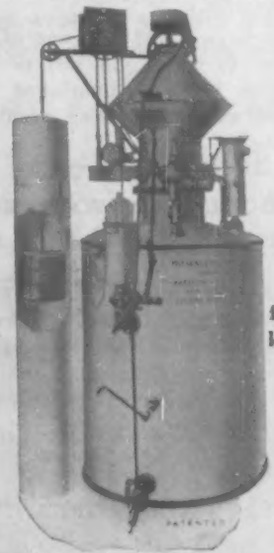

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varies with the thickness of the plates. Accordingly the efficiency of a weld depends on the properties of the base metal, the properties of the filling metal, and the thickness of the plates.

By assuming values for (1) the tensile strength of the base metal, (2) the unit tensile strength of the finished weld, and (3) the per cent excess thickness of the joint, a value can be arrived at for the efficiency of the weld that is at least consistent with the assumed conditions. Thus if the strength of the base metal is assumed to be 45,000 lb. sq. in., and the excess thickness of the joint to be 10 per cent (according to Prelimnary Report on Rules for the Construction of Unfired Pressure Vessels, Am. Soc. M. E.) and the strength of the weld is assumed to be 28,500 lb. per sq. in. (mean strength as determined by tests made), the efficiency of the joint is found to be:

$$(28{,}500)\quad (1.10)/45{,}000 = 0.70, \text{ or } 70 \text{ per cent.}$$

Again, from the results of the tests described, the efficiency of the joints may be computed:

a. As the ratio of strength per lineal inch of welded joint to strength per linear inch of plate, the value of the former being taken from Table 4 and of the latter from Table 5. So computed, the efficiency is found to be 65 per cent for ⅜-in. plate.

b. As the ratio strength per linear inch of welded point to strength per linear inch of plate, the value of the former being taken from Table 4 and of the latter being assumed as 45,000 lb. per sq. in. So computed, the efficiency is found to be 86 per cent for ⅜-in. plate.

c. As the ratio of tension per linear inch on butt joint at failure of container having longitudinal welded butt joint, to tension per linear inch on plate at failure of similar container without such joint, the value of the former being taken from the test of container No. 6 and of the latter from the test of container No. 1. So computed, the efficiency is found to be 66 per cent.

The writer believes that the correct method of computing the efficiency of an electrically welded joint is on the basis of a specified minimum strength of base metal, a specified minimum excess thickness of weld, and an experimentally determined average strength (per sq. in.) of the finished weld. This method is the one first illustrated above.

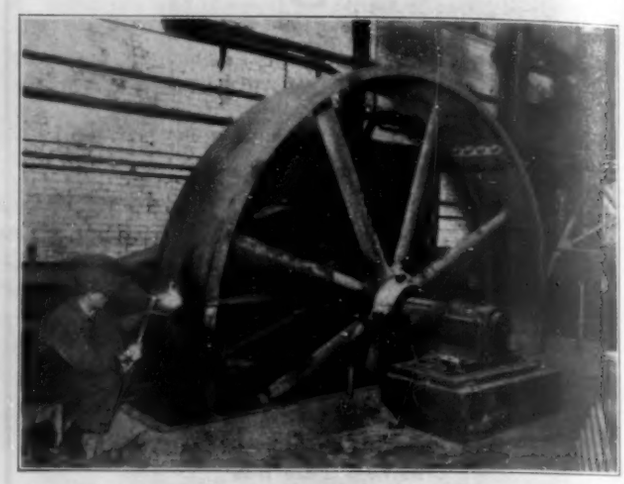
It should be stated that the results of all tests made are included in this paper, with the exception of one test made on a container of special design, which test was not completed, and one test made on a container manufactured by another company.

SOMETIMES SCRAP IS WORTH MORE THAN SALVAGE

The question when to scrap and when not to scrap, occurs with surprising frequency in demolition work. At times there is a very nice balance between the advantage of salvaging a piece of machinery or structural work and merely junking it. Since the development of cast iron cutting with oxy-acetylene the practice in this branch of demolition has undergone a very radical change, because it is now economical to reduce iron castings to charging box sizes in many instances where such a procedure could not have been considered even a couple of years ago. This is particularly true in the cutting up of very heavy iron castings such as are found in the mechanical equipment of power plants.

An interesting case in point is illustrated in the instance of a Chicago Malting Company that recently contracted with a scrap metal company to dismantle a power plant containing a large cast iron fly-wheel. Here the question arose as to whether it would be better to remove the fly-wheel in halves with a view to reassembling it as second-hand machinery, or to cut it up into such sections that it might be easily removed and broken into charging box sizes for sale as scrap. Salvaging would have required the erection of a heavy scaffold because the roof of the power house was not strong enough to allow the removal of the halves by means of block and tackle unless some supplementary support was provided. This would probably have been the procedure before cast iron cutting with oxy-acetylene was developed, because it would have been impracticable to break up the fly-wheel in place.

In the case noted the cost of the scaffolding and labor for



Oxy-Acetylene Saves Money Whether it is a Question of Salvaging or Scrapping of Metal Parts.

removal and salvage would have approximated so nearly the resale value of the fly-wheel that its reduction to scrap resulted in saving a considerable sum, even at the present low price of cast iron scrap. A picture of a service operator making the initial cut is shown here. There were eight cuts on the rim and one on each of the eight spokes. With the exception of the first cut on the rim, all were made by the contractor's own operator after witnessing the service operator's demonstration.

This is especially interesting because of the fact that cast iron cutting is new to many users of oxy-acetylene who often overlook opportunities for making appreciable savings that one familiar with this development of the process would seize upon without hesitation.

It should be perhaps stated that one of the largest items of savings on the fly-wheel job just noted was time, the scrapping operation being accomplished in hours against several days which would have been required to remove the parts for salvaging.

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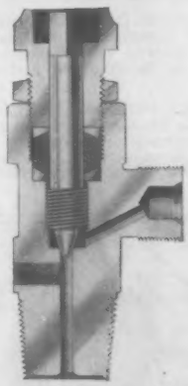

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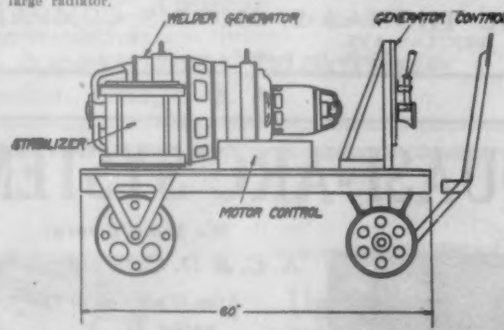

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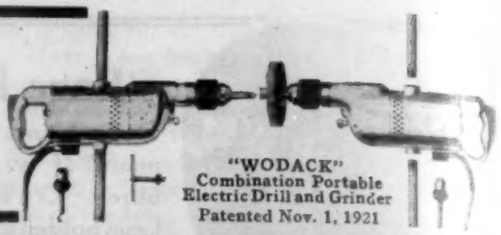
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ELECTRIC RESISTANCE RAIL JOINTS, by E. B. Entwisle—Description of the Lorain bar-weld joint and examples of its application in several large cities. Description of the butt-weld joint recently perfected.—Electric Railway Journal, June 10.

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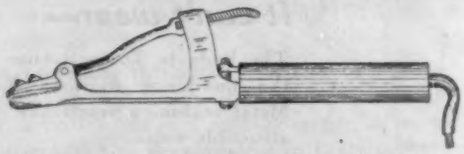
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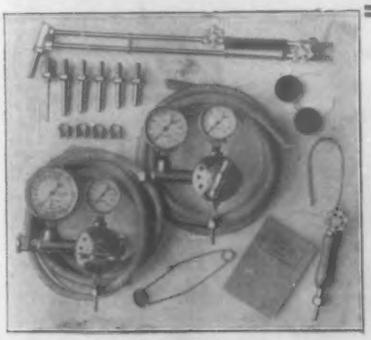

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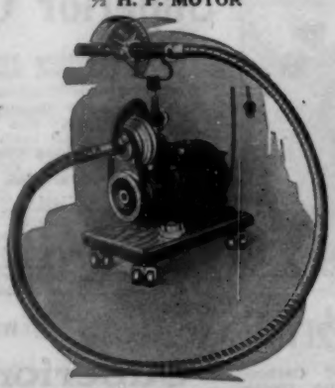

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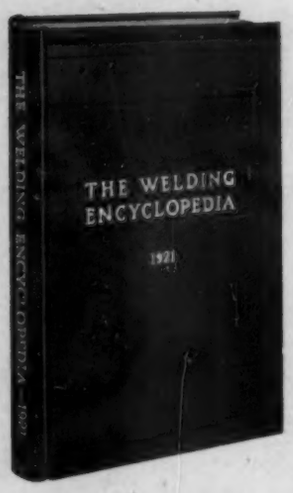

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